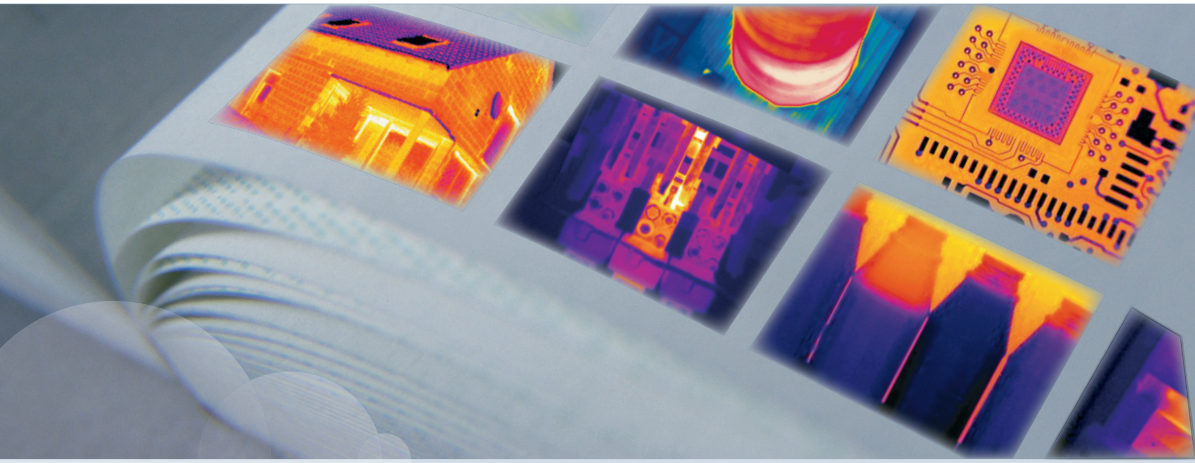
User's manual



FLIR Reporter

Version 8.5

Publ. No.	1558573
Revision	a476
Language	English (EN)
Issue date	October 18, 2010

Notice to user 1

Customer help 2

Documentation updates 3

Installation 4

Managing licenses 5

About FLIR Report Center 6

Searching for files 7

Creating a report 8

Screen elements & how to use them 9

Creating a custom report template 10

Creating Microsoft® Word document properties 11

Software reference section 12

Supported file formats in the IR Viewer object 13

About FLIR Systems 14

Thermographic measurement techniques 15

History of infrared technology 16

Theory of thermography 17

The measurement formula 18

Emissivity tables 19

Glossary 20

FLIR Reporter

User's manual

Publ. No. 1558573 Rev. a476 – ENGLISH (EN) – October 18, 2010

Legal disclaimer

All products manufactured by FLIR Systems are warranted against defective materials and workmanship for a period of one (1) year from the delivery date of the original purchase, provided such products have been under normal storage, use and service, and in accordance with FLIR Systems instruction.

Products which are not manufactured by FLIR Systems but included in systems delivered by FLIR Systems to the original purchaser, carry the warranty, if any, of the particular supplier only. FLIR Systems has no responsibility whatsoever for such products.

The warranty extends only to the original purchaser and is not transferable. It is not applicable to any product which has been subjected to misuse, neglect, accident or abnormal conditions of operation. Expendable parts are excluded from the warranty.

In the case of a defect in a product covered by this warranty the product must not be further used in order to prevent additional damage. The purchaser shall promptly report any defect to FLIR Systems or this warranty will not apply.

FLIR Systems will, at its option, repair or replace any such defective product free of charge if, upon inspection, it proves to be defective in material or workmanship and provided that it is returned to FLIR Systems within the said one-year period.

FLIR Systems has no other obligation or liability for defects than those set forth above.

No other warranty is expressed or implied. FLIR Systems specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

FLIR Systems shall not be liable for any direct, indirect, special, incidental or consequential loss or damage, whether based on contract, tort or any other legal theory.

This warranty shall be governed by Swedish law.

Any dispute, controversy or claim arising out of or in connection with this warranty, shall be finally settled by arbitration in accordance with the Rules of the Arbitration Institute of the Stockholm Chamber of Commerce. The place of arbitration shall be Stockholm. The language to be used in the arbitral proceedings shall be English.

Copyright

© 2010, FLIR Systems. All rights reserved worldwide. No parts of the software including source code may be reproduced, transmitted, transcribed or translated into any language or computer language in any form or by any means, electronic, magnetic, optical, manual or otherwise, without the prior written permission of FLIR Systems.

This documentation must not, in whole or part, be copied, photocopied, reproduced, translated or transmitted to any electronic medium or machine readable form without prior consent, in writing, from FLIR Systems.

Names and marks appearing on the products herein are either registered trademarks or trademarks of FLIR Systems and/or its subsidiaries. All other trademarks, trade names or company names referenced herein are used for identification only and are the property of their respective owners.

Quality assurance

The Quality Management System under which these products are developed and manufactured has been certified in accordance with the ISO 9001 standard.

FLIR Systems is committed to a policy of continuous development; therefore we reserve the right to make changes and improvements on any of the products described in this manual without prior notice.

Table of contents

1 Notice to user 1

2 Customer help 3

3 Documentation updates 5

4 Installation 7
- 4.1 System requirements 7
- 4.2 Installation of FLIR Reporter 8
  - 4.2.1 Windows® XP installation 8
  - 4.2.2 Windows® Vista installation 9
- 4.3 Removing FLIR Reporter 10

5 Managing licenses 11
- 5.1 Registering your product 11
- 5.2 Activating your license 12
- 5.3 Transferring your license 14
- 5.4 Updating your product 15

6 About FLIR Report Center 17

7 Searching for files 19

8 Creating a report 20
- 8.1 Creating a report using the Wizard 20

9 Screen elements & how to use them 24
- 9.1 Toolbars & toolbar buttons 24
  - 9.1.1 Main toolbar 24
  - 9.1.2 IR Viewer object toolbar 26
  - 9.1.3 IR Profile object toolbar 28
- 9.2 Infrared objects 30
  - 9.2.1 IR Viewer object 30
  - 9.2.2 IR Profile object 33
  - 9.2.3 Digital Photo object 34
  - 9.2.4 Result Table object 35

10 Creating a custom report template 37
- 10.1 A note about working in the Microsoft® Word environment 37
- 10.2 Creating a custom infrared report template 38
  - 10.2.1 About the front & back covers 39
  - 10.2.2 Creating the infrared report template pages 40
    - 10.2.2.1 Inserting IR Viewer objects and Digital Photo objects 41
    - 10.2.2.2 Inserting IR Profile objects 42
    - 10.2.2.3 Inserting Result Table objects 43
    - 10.2.2.4 Connecting objects 44
    - 10.2.2.5 Resizing infrared objects 45
    - 10.2.2.6 Moving measurement tools 46
    - 10.2.2.7 Selecting measurement tools 47
    - 10.2.2.8 Moving between measurement tools 48
    - 10.2.2.9 Cloning measurement tools 49

10.2.2.10 Deleting measurement tools ... 50
10.2.2.11 Deleting infrared objects ... 51
10.2.2.12 Deleting Result Table objects ... 52
10.3 Creating a custom infrared report template based on an existing template ... 53

11 Creating Microsoft® Word document properties ... 54
11.1 Creating & editing Microsoft® Word document properties ... 54
11.2 Creating a Microsoft® Word field and linking the field to a document property ... 56
11.2.1 In Microsoft® Word XP ... 56

12 Software reference section ... 57
12.1 FLIR Reporter menu ... 58
12.2 Shortcut menu for IR Viewer objects ... 59
12.2.1 Settings dialog box ... 61
12.2.1.1 Colors tab ... 61
12.2.1.2 Isotherms tab ... 62
12.2.1.3 Annotations tab ... 64
12.2.1.4 Object Parameters tab ... 65
12.2.1.5 Preferences tab ... 67
12.3 Shortcut menu for isotherms and IR scales ... 68
12.4 Shortcut menu for measurement tools ... 69
12.4.1 Settings dialog box ... 70
12.4.1.1 General tab ... 70
12.4.1.2 Object Parameters tab ... 71
12.4.1.3 Size/Position tab ... 72
12.5 Shortcut menu for IR Profile objects ... 73
12.5.1 Settings dialog box ... 74
12.5.1.1 General tab ... 74
12.5.1.2 Color tab ... 75
12.5.1.3 Lines tab ... 76
12.6 Shortcut menu for Digital Photo objects ... 77
12.7 Shortcut menu for Result table objects ... 78

13 Supported file formats in the IR Viewer object ... 79

14 About FLIR Systems ... 81
14.1 More than just an infrared camera ... 82
14.2 Sharing our knowledge ... 83
14.3 Supporting our customers ... 83
14.4 A few images from our facilities ... 83

15 Thermographic measurement techniques ... 85
15.1 Introduction ... 85
15.2 Emissivity ... 85
15.2.1 Finding the emissivity of a sample ... 86
15.2.1.1 Step 1: Determining reflected apparent temperature ... 86
15.2.1.2 Step 2: Determining the emissivity ... 88
15.3 Reflected apparent temperature ... 89
15.4 Distance ... 89
15.5 Relative humidity ... 89
15.6 Other parameters ... 89

16 History of infrared technology ... 91

17 Theory of thermography 95
17.1 Introduction 95
17.2 The electromagnetic spectrum 95
17.3 Blackbody radiation 96
17.3.1 Planck's law 97
17.3.2 Wien's displacement law 98
17.3.3 Stefan-Boltzmann's law 100
17.3.4 Non-blackbody emitters 101
17.4 Infrared semi-transparent materials 103

18 The measurement formula 105

19 Emissivity tables 111
19.1 References 111
19.2 Important note about the emissivity tables 111
19.3 Tables 112

20 Glossary 127

1 Notice to user

Typographical conventions

This manual uses the following typographical conventions:

- **Semibold** is used for menu names, menu commands and labels, and buttons in dialog boxes.
- *Italic* is used for important information.
- `Monospace` is used for code samples.
- UPPER CASE is used for names on keys and buttons.

User-to-user forums

Exchange ideas, problems, and infrared solutions with fellow thermographers around the world in our user-to-user forums. To go to the forums, visit:

http://www.infraredtraining.com/community/boards/

Additional license information

This software is sold under a single user license. This license permits the user to install and use the software on any compatible computer provided the software is used on only one computer at a time. One (1) back-up copy of the software may also be made for archive purposes.

INTENTIONALLY LEFT BLANK

2 Customer help

General

For customer help, visit:

http://support.flir.com

Submitting a question

To submit a question to the customer help team, you must be a registered user. It only takes a few minutes to register online. If you only want to search the knowledgebase for existing questions and answers, you do not need to be a registered user.

When you want to submit a question, make sure that you have the following information to hand:

- The camera model
- The camera serial number
- The communication protocol, or method, between the camera and your PC (for example, HDMI, Ethernet, USB™, or FireWire™)
- Operating system on your PC
- Microsoft® Office version
- Full name, publication number, and revision number of the manual

Downloads

On the customer help site you can also download the following:

- Firmware updates for your infrared camera
- Program updates for your PC software
- User documentation
- Application stories
- Technical publications

INTENTIONALLY LEFT BLANK

3 Documentation updates

General

Our manuals are updated several times per year, and we also issue product-critical notifications of changes on a regular basis.

To access the latest manuals and notifications, go to the Download tab at:

http://support.flir.com

It only takes a few minutes to register online. In the download area you will also find the latest releases of manuals for our other products, as well as manuals for our historical and obsolete products.

INTENTIONALLY LEFT BLANK

4 Installation

4.1 System requirements

Operating system

- Microsoft® Windows® XP Pro, 32-bit, with Service Pack 3 (SP3)
- Microsoft® Windows® Vista, 32- and 64-bit, with Service Pack 1 (SP1)
- Microsoft® Windows® 7, 32- and 64-bit

Hardware

Microsoft® Windows® XP:

- Personal computer with an Intel® 800 MHz Pentium processor, or an AMD Opteron, AMD Athlon 64, or AMD Athlon XP processor
- 512 MB of RAM, or greater
- 20 GB of available hard disk space
- CD-ROM or DVD-ROM drive
- Super VGA (1024 × 768) or higher-resolution monitor
- Internet access required for web updates
- Keyboard and Microsoft® mouse, or a compatible pointing device

Microsoft® Windows® Vista:

- Personal computer with a 1 GHz 32-bit (x86) processor
- 1 GB of RAM, or greater
- 40 GB hard disk, with at least 15 GB available hard disk space
- DVD-ROM drive
- Support for DirectX 9 graphics with:
  - WDDM Driver
  - 128 MB of graphics memory (minimum)
  - Pixel Shader 2.0 in hardware
  - 32 bits per pixel
- Super VGA (1024 × 768) or higher-resolution monitor
- Internet access (fees may apply)
- Audio output
- Keyboard and Microsoft® mouse, or a compatible pointing device

Software

- Microsoft® Office® 2003 with Service Pack 3 (SP3)
- Microsoft® Office® 2007 with Service Pack 1 (SP1)

Related topics

For specific information about system requirements for the operating systems mentioned above, please visit: http://www.microsoft.com/windows/

4.2 Installation of FLIR Reporter

4.2.1 Windows® XP installation

NOTE

- If your software license agreement depends on using a security device, insert the security device in an available USB connector of the computer before you enter the license number.
- The license number is printed on the back of the CD-ROM case.

Procedure

Follow this procedure to install FLIR Reporter on your computer:

1	Do one of the following: ■ If a previous program version of FLIR Reporter *is* installed on your computer, remove this version by using the Microsoft® Windows **Add or Remove Programs** procedure (**Start** → **Settings** → **Add or Remove Programs**). ■ If a previous program version of FLIR Reporter is *not* installed on your computer, go to Step 2 below.
2	Close down all running programs, including Microsoft® Outlook.
3	Insert the FLIR Reporter CD-ROM into the CD-ROM drive on the computer. The installation should start automatically. Should the installation not start automatically, start Windows® Explorer and double-click SETUP.EXE on the CD-ROM.
4	Follow the on-screen instructions.

NOTE

- A Neevia docCreator will be added to your computer by this installation procedure.
- After installation, make sure the security level for macros in Microsoft® Word is not set to **Very high** (**Tools** → **Macros** → **Security**). If it is, set it to **High**.
- When opening a report, you will be asked whether to disable or enable the macros. Always click **Enable Macros**.

4.2.2 Windows® Vista installation

NOTE

- If your software license agreement depends on using a security device, insert the security device in an available USB connector of the computer before you enter the license number.
- The license number is printed on the back of the CD-ROM case.

Procedure

Follow this procedure to install FLIR Reporter:

1	Do one of the following: ▪ If a previous program version of FLIR Reporter *is* installed on your computer, remove this version by using the Microsoft® Windows **Add or Remove Programs** procedure (**Start** → **Settings** → **Add or Remove Programs**). ▪ If a previous program version of FLIR Reporter is *not* installed on your computer, go to Step 2 below.
2	Close down all running programs, including Microsoft® Outlook.
3	Insert the FLIR Reporter CD-ROM into the CD-ROM drive on the computer. The installation should start automatically. Should the installation not start automatically, start Windows® Explorer and double-click SETUP.EXE on the CD-ROM.
4	In the **Autoplay** dialog box, click **Run setup.exe (Published by FLIR Systems)**.
5	In the **User Account Control** dialog box, confirm that you want to install FLIR Reporter.
6	Follow the on-screen instructions.

NOTE

- A Neevia docCreator will be added to your computer by this installation procedure.
- After installation, make sure the security level for macros in Microsoft® Word is not set to **Very high** (**Tools** → **Macros** → **Security**). If it is, set it to **High**.
- When opening a report, you will be asked whether to disable or enable the macros. Always click **Enable Macros**.

4.3 Removing FLIR Reporter

Procedure

Follow this procedure to remove FLIR Reporter from your computer:

1	Close down all applications.
2	Insert the FLIR Reporter CD-ROM into the CD-ROM drive on the computer.
3	When the InstallShield Wizard dialog box is displayed, do the following: **1** Click **Remove**. **2** Click **Next**. **3** Follow the on-screen instructions.

NOTE

You can also remove FLIR Reporter from your computer by using the Microsoft® Windows **Add or Remove Programs** procedure (**Start** → **Settings** → **Add or Remove Programs**.

5 Managing licenses

5.1 *Registering your product*

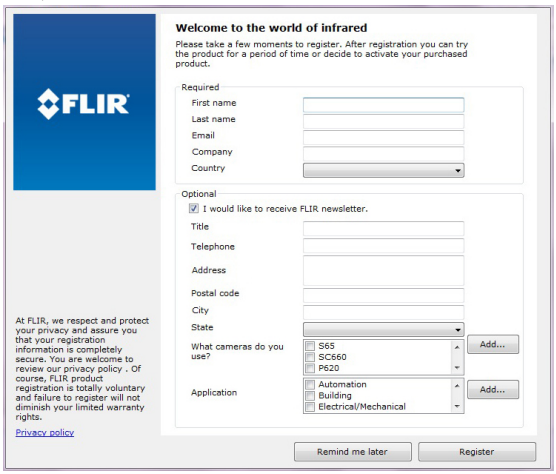
General

It is important that you register your product. By registering your product you are entitled to:

- Free program updates
- Free unlimited technical support at http://flir.custhelp.com
- Timely information about new releases

Figure

T638251;a1



Procedure

To register your product, fill in the required fields and click **Register**.

5.2 Activating your license

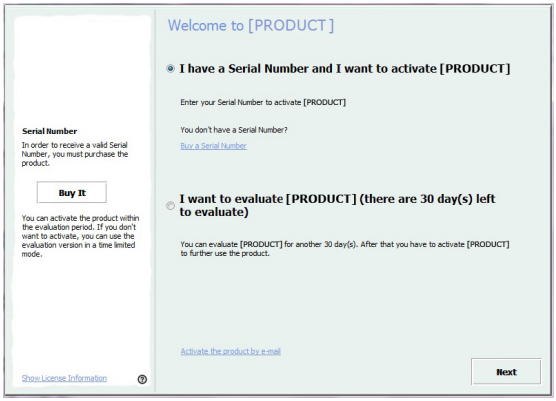
General

The first time you start FLIR Reporter you will be able to choose one of the following options:

- Activate FLIR Reporter online.
- Activate FLIR Reporter by e-mail.
- Purchase FLIR Reporter and receive a serial number for activation.
- Use FLIR Reporter for free during an evaluation period.

Figure

T638252;a1


Welcome to [PRODUCT]
I have a Serial Number and I want to activate [PRODUCT]
Enter your Serial Number to activate [PRODUCT]
You don't have a Serial Number?
Buy a Serial Number
I want to evaluate [PRODUCT] (there are 30 day(s) left to evaluate)
You can evaluate [PRODUCT] for another 30 day(s). After that you have to activate [PRODUCT] to further use the product.
Activate the product by e-mail
Next
Serial Number
In order to receive a valid Serial Number, you must purchase the product.
Buy It
You can activate the product within the evaluation period. If you don't want to activate, you can use the evaluation version in a time limited mode.
Show License Information

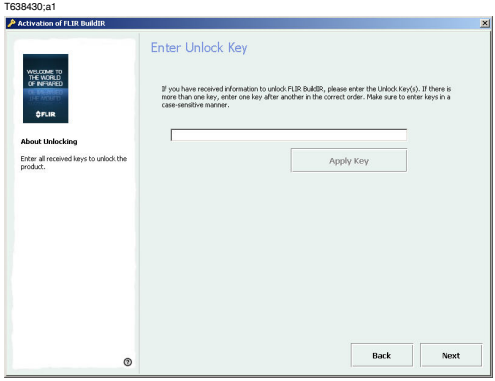
Activating FLIR Reporter online

Follow this procedure:

1	Start FLIR Reporter.
2	In the web activation dialog box, select **I have a Serial Number and I want to activate FLIR Reporter**.
3	Click **Next**.
4	Enter your serial number, name, company and e-mail address. The name should be the name of the license holder.
5	Click **Next**.
6	Click **Activate now**. This will start the web activation process.
7	When the message **Online activation was successful** is displayed, click **Close**. You have now successfully activated FLIR Reporter.

Activating FLIR Reporter by e-mail

Follow this procedure:

1	Start FLIR Reporter.
2	In the web activation dialog box, click **Activate the product by e-mail**.
3	Enter your serial number, name, company and e-mail address. The name should be the name of the license holder.
4	Click **Request Unlock Key by E-mail**.
5	Your default e-mail client now opens and an unsent e-mail with license information is displayed. **Send this e-mail without altering the content**. The main purpose of the e-mail is to send the license information to the activation center.
6	Click **Next**. The program will now start and you can continue working while waiting for the unlock key. You should receive an e-mail with the unlock key within two days.
7	When the e-mail with the unlock key arrives, start the program and enter the unlock key in the text box. See the figure below. T638430;a1 

5.3 Transferring your license

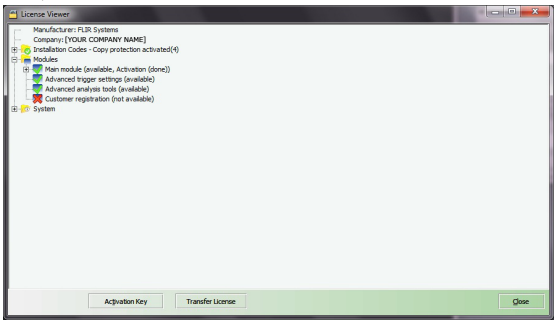
General

You can transfer a license from one computer to another computer, as long as you do not exceed the number of purchased licenses on one computer at the same time.

This lets you use the software on, for example, a desktop and a laptop computer.

Figure

T638254;a1



Procedure

Follow this procedure to transfer a license:

1	Start FLIR Report Center (**Start** > **FLIR Systems** > **FLIR Report Center**).
2	On the **Help** tab, select **Show license information**. This will display the license viewer shown above.
3	In the license viewer, click **Transfer license**. This will display a deactivation dialog box.
4	In the a deactivation dialog box, click **Deactivate**.
5	On the computer to which you want to transfer the license, start FLIR Reporter. As soon as the computer gets Internet access, the license will be automatically adopted.

NOTE

The adoption of licenses is based on a “first-come, first-serve” concept. This means that the *first* computer that gets Internet access automatically adopts the transferred license.

5.4 Updating your product

General

We regularly issue software updates and you can update the program using this update service.

Procedure

Follow this procedure to check for updates:

1	On the **Start** menu, select **Programs** > **FLIR Systems** > **FLIR Reporter** > **Check for updates**.
2	Follow the on-screen instructions.

NOTE

Some programs from FLIR Systems also support updating from within the application.

INTENTIONALLY LEFT BLANK

Publ. No. 1558573 Rev. a476 – ENGLISH (EN) – October 18, 2010

6 About FLIR Report Center

General

When you install FLIR Reporter, FLIR Report Center will also be installed. FLIR Report Center is a good starting point to begin working with infrared reports.

Where do I find FLIR Report Center?

You find FLIR Report Center under **Programs** on the **Start** menu (**Start** → **Programs** → FLIR Systems → FLIR Report Center).

How to use FLIR Report Center

In FLIR Report Center, you can do one or more of the following:

- Automatically download program updates and news
- Get access to the online help files for FLIR Reporter
- Find tutorials on how to create reports, report templates, and more
- Find system information about your computer

INTENTIONALLY LEFT BLANK

Publ. No. 1558573 Rev. a476 – ENGLISH (EN) – October 18, 2010

7 Searching for files

General

After you have installed FLIR Reporter, a task pane will be displayed to the right in Microsoft® Word. At the top of the task pane, you can search for infrared images and digital photos on your hard disk drive. You can then move these files to your report or report template by using a drag-and-drop operation.

About search parameters

The search engine is an *exact match* search engine and accepts alphabetic characters (a–z, A–Z) and numerical characters (0–9). However, numerical characters will be treated as text.

When you enter a search string the search engine searches for this string in any location of a file. This means that a search string such as '25' can, for example, return the following results:

- IR_0025.jpg ('25' in the file name)
- An image file with a modified date containing '25'

About boolean operators

You can combine search strings using boolean operators. Example:

- To find an image file that contains both a text comment containing '10' and a spotmeter that has a measurement result of +25°C, use the AND boolean operator.
- To find all files that either contains a text comment containing '10' or a spotmeter that has a measurement result of +25°C, use the OR boolean operator.

However, you can not use boolean operators in the following two example cases:

- To search for IR_0025.jpg ('25' in the file name) and a spotmeter that has a measurement result of +25°C
- To search for IR_0025.jpg ('25' in the file name) or a spotmeter that has a measurement result of +25°C

Procedure

Follow this procedure to search for the files you have indexed:

1	In the task pane in Microsoft® Word, type a search string.
2	To start the search, click **Go**. The search engine will now search through all indexed files on your computer and display thumbnail images in the result table. You can now move one or several files to the report or report template by using a drag-and-drop operation.

NOTE

The task pane will not be displayed if you have one of the following Microsoft® Office versions:

- Microsoft® Office 2003 Standard
- Microsoft® Office 2007

8 Creating a report

8.1 Creating a report using the Wizard

General

Using the Wizard gives you opportunities to fine-tune and adjust your report before it is created.

In the Wizard you can select different report templates for different pages, move pages up and down, and so on.

NOTE

Before your create an infrared report, a report template (a Microsoft® Word *.dot file) must have been previously created. However, FLIR Reporter ships with several different report templates, which you may find useful.

Different ways to start the Wizard

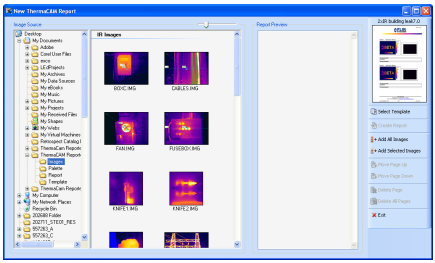
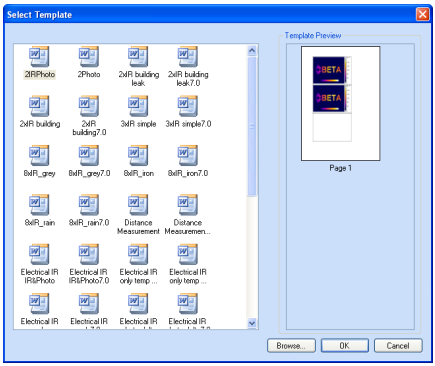
You can start the Wizard in three different ways:

- By going to the **Start** menu and selecting a task on the program menu (**Start** → **Programs** → FLIR Systems → FLIR Reporter).
- By going to the **Start** menu and selecting a task using FLIR Report Center (**Start** → **Programs** → FLIR Systems → FLIR Report Center).
- By clicking the FLIR button on the main toolbar.

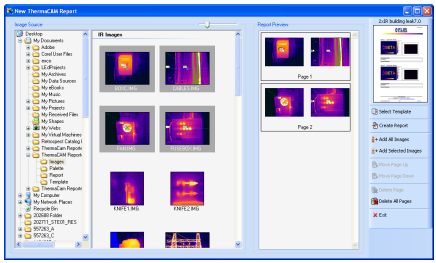
INTENTIONALLY LEFT BLANK

Procedure

Follow this procedure to create a report using the Wizard:

1	Start the Wizard.
2	In the left pane, go to a folder that contains infrared and visual images that you want to use. When you have selected a folder, the images will be displayed in the middle pane. You can change the size of the thumbnail images by moving the slider at the top of the middle pane. 10743003;a2 
3	To select the template you want to use, click **Select Template** and select a template. A preview of each page in the report template will be displayed in the preview window. If the report template contains several pages, you must select which page you want to base your report on. Click **OK** 10743103;a2 

8

4	Select the images you want to include in your report. To add them to your report template, do one of the following: ■ Move the images to the right pane using a drag-and-drop operation. ■ Add the image or images to the right pane by right-clicking an image and selecting **Add All Images** or **Add Selected Images**. ■ Click **Add All Images** or **Add Selected Images**. 10743203;a2 
5	To further modify your report, do one of the following: ■ To change the order of pages, click **Move page up** or **Move page down**. ■ To delete pages, click **Delete Page** or **Delete all pages**. ■ To replace an image in the report, move another image to the location of the image you want to replace.
6	To create the report, click **Create Report**.

Related topics

Section 10 – Creating a custom report template on page 37

9 Screen elements & how to use them

9.1 Toolbars & toolbar buttons

9.1.1 Main toolbar

NOTE

- If you do not see the main toolbar, select the toolbar on the **Toolbars** menu (**View** → **Toolbars** → FLIR Reporter).
- You usually only insert infrared objects from the main toolbar when you design a custom report template from scratch, or when you modify an existing report template.

Figure

10742903;a1

Explanation

This table gives an explanation to the figure above:

	Click to insert an IR Viewer object for infrared images and sequence file. An infrared image or sequence file contains valid temperature information that may be output by overlaying different kinds of measurement tools, such as spotmeters, profiles, areas, etc.
	Click to insert an IR Profile object. An IR Profile object contains a graph showing pixel values along a line in an infrared image.
	Click to insert a Digital Photo object. This photo may be taken with a stand-alone digital camera, or with the digital visual camera featured on some FLIR Systems infrared cameras. Only use this method to insert a photo when you design a report template. In all other situations, insert photos by clicking **Picture** on the **Insert** menu (**Insert** → **Picture** → **From File**).
	Click to insert an Result Table object into your current document. A Result Table object displays the results of the measurement tools laid out in the infrared image, as well as other information that is related to the infrared image.
	Click this toolbar button and then click an infrared object to remove the infrared object from your report.
	Click to connect infrared objects to each other—for example, an IR Profile object to an IR Viewer object.
	Click to enter the design mode of Microsoft® Word. Use this mode when creating report templates and when you want to select and move objects.

	Click to create an Adobe® PDF document of the Microsoft® Word document. A free version of Adobe® Reader is available from http://adobe.com/products/acrobat/readstep2.html.
	Click to display the task pane.
	Click to display online help.

9.1.2 IR Viewer object toolbar

General

This toolbar is only displayed when an IR Viewer object is selected.

Figure

10733903;a2

Explanation

This table gives an explanation to the figure above:

	Click to display the selection tool, which works similar to other selection tools in word processing and desktop publishing programs. You use the selection tool to select measurement tools.
	Click to display a spotmeter with an attached flag that you can use to identify temperature values by moving it over the infrared image. If you click the image, the flying spotmeter tool will create a fixed spotmeter on the image. To stop the flying spotmeter mode, press ESC.
	Click to create fixed spotmeters on infrared images. The measurement result can then be displayed in a Result Table object.
	Click to create areas on infrared images. The measurement result can then be displayed in a Result Table object.
	Click to create ellipsoidal areas on infrared images. The measurement result can then be displayed in a Result Table object.
	Click to create polygon areas on infrared images. The measurement result can then be displayed in a Result Table object.
	Click to create a line on infrared images. The measurement result can then be displayed in an IR Profile object.
	Click to create a bent line on infrared images. The measurement result can then be displayed in an IR Profile object.
	Click to calculate the difference between two temperatures—for example, two spotmeters, or a spotmeter and the maximum temperature in the image. The result from the calculation will be displayed both as a ToolTip, and as a result in the result table. Using this toolbar button requires that you have laid out at least one measurement function on your image.
	Click to create a marker that you can move anywhere in an image and point to an area of interest.

	Click to display a menu where you can do one of the following: ■ Insert an isotherm between two temperature levels. This assigns a color to all temperatures between two temperature levels in an image with one preset color. ■ Insert an isotherm above a temperature level. This assigns a color to all temperatures above a certain temperature level in an image with one preset color. ■ Insert an isotherm below a temperature level. This assigns a color to all temperatures below a certain temperature level in an image with one preset color. ■ Set an isotherm color that is displayed when the camera detects an area where there may be a risk of humidity in the building structure (a humidity alarm). ■ Set an isotherm color that is displayed when the camera detects what may be an insulation deficiency in a wall (an insulation alarm). For more information about alarms, see section 12.2.1.2 – Isotherms tab on page 62.
	Click to draw a rectangle around the area you want to zoom in on. When you are in zoom mode, a thumbnail image will appear in the top right corner, indicating the location of the area you have zoomed in to. You can move the area by clicking and holding down the left mouse button, then moving the mouse in any direction. To leave the zoom mode, either select **1×** on the **Zoom** menu, or press the space bar on the keyboard.
	Click to fuse an infrared image with a digital photo. Fusing images can make it easier to identify the exact position of temperature anomalies.

Related topics

- Section 10.2.2.1 – Inserting IR Viewer objects and Digital Photo objects on page 41
- Section 10.2.2.6 – Moving measurement tools on page 46
- Section 10.2.2.7 – Selecting measurement tools on page 47
- Section 10.2.2.8 – Moving between measurement tools on page 48
- Section 10.2.2.9 – Cloning measurement tools on page 49
- Section 10.2.2.10 – Deleting measurement tools on page 50
- Section 10.2.2.11 – Deleting infrared objects on page 51
- Section 12.2 – Shortcut menu for IR Viewer objects on page 59

9.1.3 IR Profile object toolbar

General

This toolbar is only displayed when an IR Profile object is selected.

Figure

10734003;a1

Explanation

This table gives an explanation to the figure above:

	Click to create a three-dimensional rendering of the graph of the IR Profile object.
	Click to turn on/turn off the grid lines in the graph of the IR Profile object.

Related topics

- Section 10.2.2.2 – Inserting IR Profile objects on page 42
- Section 10.2.2.5 – Resizing infrared objects on page 45
- Section 10.2.2.11 – Deleting infrared objects on page 51
- Section 12.5 – Shortcut menu for IR Profile objects on page 73

INTENTIONALLY LEFT BLANK

9.2 Infrared objects

9.2.1 IR Viewer object

NOTE

You usually only insert an IR Viewer object when designing a custom report template.

Inserting an IR Viewer object

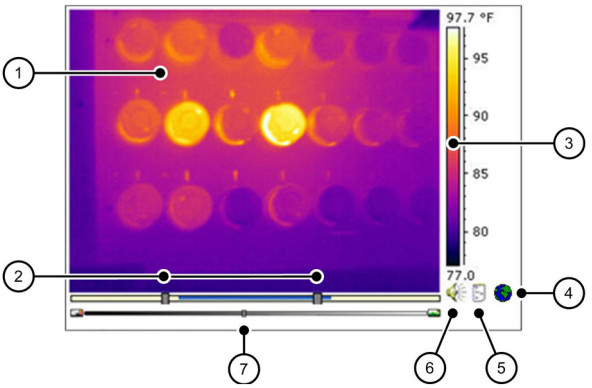
To insert an IR Viewer object, click on the main toolbar.

Displaying the toolbar

To display the toolbar for this object, select the object with the cursor.

An IR Viewer object with an infrared image

1075830 3;a2



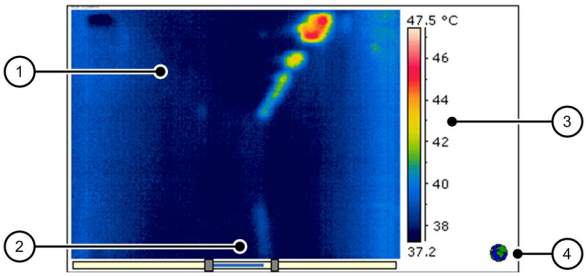
Callouts

This table gives information to the figure above:

1	Infrared image
2	Sliders to adjust level and span
3	Temperature scale
4	Indicator that the image file has embedded GPS data. Click the globe to display the position on a map.
5	Indicator that the image file has a text comment.
6	Indicator that the image file has a voice comment.
7	Slider to control image fusion. Drag the slider left or right to fuse an infrared image with a digital photo. For more information about image fusion, see section 12.2 – Shortcut menu for IR Viewer objects on page 59.

An IR Viewer object with a sequence file

T638210;a1



Callouts

This table gives information to the figure above:

1	Infrared sequence (first frame only)
2	Sliders to adjust scale limits
3	Temperature scale
4	Indicator that the image file has embedded GPS data. Click the globe to display the position on a map.

Explanation

An IR Viewer object is a placeholder for infrared images and sequence files. An infrared image contains valid temperature information that may be output by overlaying different kinds of measurement tools, such as spotmeters, profiles, areas, etc.

Common tasks

Common tasks related to the IR Viewer object include the following:

- To change the scale limits, move the sliders left or right.
- To control image fusion, drag the slider left or right to fuse an infrared image with a digital photo. You can also use one of the following shortcuts to control image fusion:
  - To go to fully infrared image or fully digital photo, click the corresponding icon at the left or right end of the gauge.
  - To center the slider on the gauge, right-click the gauge.
  - To move the slider to a specific position on the gauge, double-click the gauge at that position.
  - To move the slider in small increments to the left or to the right, click the gauge to the left or to the right of the slider.

  For more information about image fusion, see section 12.2 – Shortcut menu for IR Viewer objects on page 59.
- To auto-adjust an image for best image brightness and contrast, right-click one of the sliders.
- To move both sliders together, press and hold SHIFT and move one of the sliders.
- To open a new infrared image, or view the first frame of a sequence file, double-click the IR Viewer object. You can also right-click the IR Viewer object and select **Open**.

- To play back a voice comment, click the voice comment symbol. The voice comment symbol is only visible when the image has a voice comment.
- To see a text comment, click the text comment symbol. The text comment symbol is only visible when the image has a text comment.
- To display the position where the image was taken on a map, click the globe symbol. This requires that the image contains GPS data.
- To insert measurement tools, click the appropriate toolbar button.
- To save under a different file name, right-click the image and select **Save As**.
- To zoom in on an image, right-click the image and select **Zoom**.
- To change settings related to colors, isotherms, text comments, object parameters and preferences, right-click the image and select **Settings**.
- To rotate the image left or right, right-click the image and select **Rotate Left** or **Rotate Right**.
- To insert measurement tools using a menu instead of the toolbar buttons, right-click the image and select a measurement tool on the **Measurement** submenu.

Related topics

- Section 9.1.2 – IR Viewer object toolbar on page 26
- Section 10.2.2.1 – Inserting IR Viewer objects and Digital Photo objects on page 41
- Section 10.2.2.5 – Resizing infrared objects on page 45
- Section 10.2.2.11 – Deleting infrared objects on page 51
- Section 12.2 – Shortcut menu for IR Viewer objects on page 59

9.2.2 IR Profile object

NOTE

You usually only insert an IR Profile object when designing a custom report template.

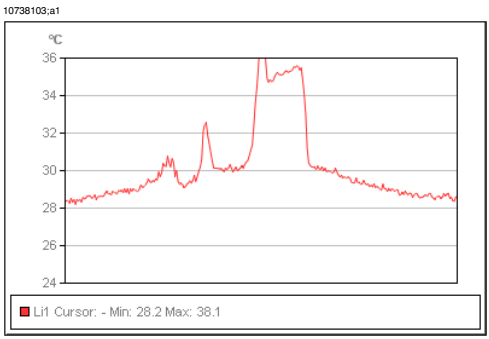
Inserting an IR Profile object

To insert an IR Profile object, click on the main toolbar.

Displaying the toolbar

To display the toolbar for this object, select the object with the cursor.

Figure



Explanation

An IR Profile object contains a graph showing pixel values along a line in an infrared image.

Common tasks

Common tasks related to the IR Profile object include the following:

- To create a three-dimensional rendering, click the appropriate toolbar button or right-click the IR Profile object and select **3D View**.
- To turn on/turn off the grid lines, click the appropriate toolbar button or right-click the IR Profile object and select **Grid Lines**.
- To turn on/turn off the legend, right-click the IR Profile object and select **Legend**.
- To swap X- and Y-axes, right-click the IR Profile object and select **Swap X & Y Axes**.
- To change settings related to general settings, color and lines, right-click the IR Profile object and select **Settings**.

Related topics

- Section 9.1.3 – IR Profile object toolbar on page 28
- Section 10.2.2.2 – Inserting IR Profile objects on page 42
- Section 10.2.2.5 – Resizing infrared objects on page 45
- Section 10.2.2.11 – Deleting infrared objects on page 51
- Section 12.5 – Shortcut menu for IR Profile objects on page 73

9.2.3 Digital Photo object

NOTE

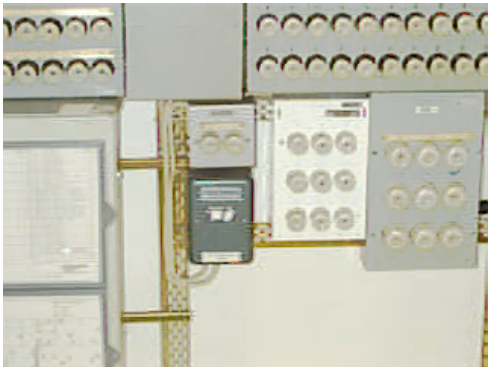
Only use this method to insert a photo when designing a report template. In all other situations, insert photos by clicking **Picture** on the **Insert** menu (**Insert** → **Picture** → **From File**).

Inserting a Digital Photo object

To insert a Digital Photo object, click on the main toolbar.

Figure

10738303;a1



Explanation

The Digital Photo object is a placeholder for photos. This photo may be taken with a stand-alone digital camera, or with the digital visual camera featured on some FLIR Systems infrared cameras.

Common tasks

To open a new image, right-click the Digital Photo object and select **Open**.

Related topics

- Section 10.2.2.1 – Inserting IR Viewer objects and Digital Photo objects on page 41
- Section 10.2.2.5 – Resizing infrared objects on page 45
- Section 10.2.2.11 – Deleting infrared objects on page 51
- Section 12.6 – Shortcut menu for Digital Photo objects on page 77

9.2.4 Result Table object

NOTE

- You usually only insert a Result Table object when designing a custom report template.
- You can edit the texts in the Result Table object, once the report is created. However, these changes will be deleted when you right-click the Result Table object and select **Refresh**.

Inserting a Result Table object

To insert an Result Table object, click on the main toolbar.

Figure

10738403;a1

Title	IR_0147.jpg
Image MAX	39.2 °C
Image MIN	25.9 °C

Explanation

A Result Table object displays the results of the measurement tools laid out in the infrared image, as well as other information that is related to the infrared image.

Common tasks

Common tasks related to the Result table object include the following:

- To change borders and shading of the Result Table object, right-click the Result Table object and select **Borders and Shading**. This is a standard Microsoft® Word feature.
- To spell-check the texts in the Result Table object, right-click the Result Table object and select **Spelling**. This is a standard Microsoft® Word feature.
- To specify what information should be displayed in the Result Table object, right-click the Result Table object and select **Contents**.
- To refresh the Result Table object contents, right-click the Result Table object and select **Refresh**. You usually only have to do this if you have changed the contents manually.

New feature in version 8.5 SP1

A major new feature in version 8.5 SP1 is the ability to retrieve any existing MeterLink data from an infrared image and display this data in the result table. MeterLink data can be stored in the infrared image by using an external Extech® sensor—such as a clamp meter or a moisture meter—together with the infrared camera.

In FLIR Reporter, you can retrieve the MeterLink data from the infrared image by selecting an Extech® sensor in the left pane (e.g., EX845) and then selecting a value in the right pane (e.g., capacitance).

For information on how to include MeterLink data in an infrared image when using the camera, refer to the user documentation for one of the following camera series:

- FLIR bXX series
- FLIR iXX series
- FLIR BXXX series
- FLIR TXXX series

Related topics

- Section 10.2.2.3 – Inserting Result Table objects on page 43
- Section 10.2.2.5 – Resizing infrared objects on page 45

- Section 10.2.2.12 – Deleting Result Table objects on page 52
- Section 12.7 – Shortcut menu for Result table objects on page 78

10 Creating a custom report template

10.1 A note about working in the Microsoft® Word environment

General

Due to the fact that FLIR Reporter is an add-in to Microsoft® Word, basically all existing features you usually use when creating a Microsoft® Word document template can be used when creating your report templates.

FLIR Reporter adds a number of commands that are specific to the industry of infrared imaging and reporting, and these commands can be accessed on the FLIR Reporter menu as well as on the different toolbars.

You use these features, along with the usual Microsoft®Word features, when you create infrared report templates.

NOTE

- Creating a report template requires skill in creating document templates in Microsoft® Word. For more information about this, please refer to your Microsoft® Word documentation, or the Microsoft® Word online help.
- When creating a custom report template, you may it useful to select **Show**/**Hide ¶** on the main toolbar in Microsoft® Word.

10.2 Creating a custom infrared report template

Typical structure of a report template

A custom infrared report template usually consists of the following types of pages:

- A front cover
- A number of different pages, containing combinations of IR Viewer objects, Digital Photo objects, Result Table objects, etc.
- A back cover

Few or many report templates?

It is not uncommon that you will use one specific template for one specific customer. If this is the case, you may want to include your customer's company-specific information in the template, rather than entering it manually after the infrared report has been generated.

Consequently, if several of your customers request an infrared report that could be met with one, or a few, single templates, company-specific information should probably not be included in the template, since that kind of information may easily be entered after the Wizard has generated the report.

Related topics

- Section 10.2.1 – About the front & back covers on page 39
- Section 10.2.2 – Creating the infrared report template pages on page 40

10.2.1 About the front & back covers

General

You create the front and back covers of the report template using existing features in Microsoft® Word.

Types of information

The front and back covers of an infrared report template typically include the following information:

- Your and your customer's company names
- Other contact information
- Current date
- Title of the infrared report
- Your and your customer's company logotypes
- Any additional artwork or information that you may want to include

10.2.2 Creating the infrared report template pages

General

You create an infrared report page either by clicking the buttons on the FLIR Reporter toolbar, or by clicking the commands on the FLIR Reporter menu.

Types of infrared objects

There are three different infrared objects and one table object:

- IR Viewer object
- Digital Photo object
- IR Profile object
- Result table object

NOTE

The procedures on the following pages assume that you click the toolbar buttons. However, you can also click the commands on the FLIR Reporter menu.

Related topics

- Section 10.2.2.1 – Inserting IR Viewer objects and Digital Photo objects on page 41
- Section 10.2.2.2 – Inserting IR Profile objects on page 42
- Section 10.2.2.3 – Inserting Result Table objects on page 43
- Section 10.2.2.4 – Connecting objects on page 44
- Section 10.2.2.5 – Resizing infrared objects on page 45
- Section 10.2.2.6 – Moving measurement tools on page 46
- Section 10.2.2.7 – Selecting measurement tools on page 47
- Section 10.2.2.8 – Moving between measurement tools on page 48
- Section 10.2.2.9 – Cloning measurement tools on page 49
- Section 10.2.2.10 – Deleting measurement tools on page 50
- Section 10.2.2.11 – Deleting infrared objects on page 51
- Section 10.2.2.12 – Deleting Result Table objects on page 52

10.2.2.1 Inserting IR Viewer objects and Digital Photo objects

Procedure

Follow this procedure to insert IR Viewer objects and Digital Photo objects:

1	On your template page, place the cursor where you want the IR Viewer object or Digital Photo object to appear. The placeholders will be inserted *after and below* the cursor.
2	On the toolbar, click (for an IR Viewer object) or (for a Digital Photo object). An placeholder will now appear on the page. Since you are creating a template, you should not open any infrared images or photos at this stage.

Related topics

- Section 9.1.2 – IR Viewer object toolbar on page 26
- Section 9.2.1 – IR Viewer object on page 30
- Section 9.2.3 – Digital Photo object on page 34
- Section 12.2 – Shortcut menu for IR Viewer objects on page 59

10.2.2.2 Inserting IR Profile objects

Procedure

Follow this procedure to insert an IR Profile object:

1	On your template page, click where you want the IR Profile object to appear. The IR Profile object will be inserted *after and below* the cursor.
2	On the toolbar, click . An empty IR Profile object will now appear on your page. When you create your report, the IR Profile object will automatically display the values of any line tools that are saved in the infrared image.

Related topics

- Section 9.1.3 – IR Profile object toolbar on page 28
- Section 9.2.2 – IR Profile object on page 33
- Section 12.5 – Shortcut menu for IR Profile objects on page 73

10.2.2.3 Inserting Result Table objects

Procedure

Follow this procedure to insert a Result Table object:

1	On your template page, click where you want the Result Table object to appear. The Result Table object will be inserted *after and below* the cursor.
2	On the toolbar, click . A Result Table object will now appear on your page. When you create your report, the Result Table object will automatically display the values of any measurement tools in the infrared image.

NOTE

If a result table is connected to an infrared image and you delete either the table or the image, you will not be able to recreate the connection again.

Related topics

- Section 9.2.4 – Result Table object on page 35
- Section 12.7 – Shortcut menu for Result table objects on page 78

10.2.2.4 Connecting objects

NOTE

- This description assumes that you have one IR Viewer object and one IR Profile object on your template page.
- The objects you connect must be on the same page when you connect them. If the document is repaginated and one of the objects falls on a different page the connection will, however, still be maintained.

Procedure

On the main toolbar, click . This will display a dialog box where you can select the IR Viewer object you want to connect the IR Profile object to.

10.2.2.5 Resizing infrared objects

Procedure

Follow this procedure to resize an infrared object:

1	Click anywhere on an IR Viewer object, a Digital Photo object, etc.
2	To change the size, drag one of the handles that will be displayed when you select the object.

NOTE

The procedure above does not apply to resizing Result Table objects. To resize these types of objects, select the object and use the menu commands on the **Table** menu.

Related topics

Section 9.2 – Infrared objects on page 30

10.2.2.6 Moving measurement tools

Procedure

Follow this procedure to move a measurement tool:

1	Select one or several measurement tools according to section 10.2.2.7 – Selecting measurement tools on page 47.
2	Do one of the following: ▪ To move the measurement tool, press the arrow keys. ▪ To move the measurement tool, use the mouse.

Related topics

- Section 9.1.2 – IR Viewer object toolbar on page 26
- Section 9.2.1 – IR Viewer object on page 30

10.2.2.7 Selecting measurement tools

Procedure

Do one of the following:

- To select one tool, click the tool.
- To select several tools, SHIFT-click the tools.
- To select all tools, select the IR Viewer object and press A.
- To select one or several tools, click and draw a rectangle around the tools you want to select.

Related topics

- Section 9.1.2 – IR Viewer object toolbar on page 26
- Section 9.2.1 – IR Viewer object on page 30

10.2.2.8 Moving between measurement tools

Procedure

Do one of the following:

- To select one tool after another, in one direction, press TAB.
- To select one tool after another, in the other direction, press and hold SHIFT and then press TAB.

Related topics

- Section 9.1.2 – IR Viewer object toolbar on page 26
- Section 9.2.1 – IR Viewer object on page 30

10.2.2.9 Cloning measurement tools

Procedure

To clone a measurement tool, press and hold CTRL when you move the measurement tool. This will create a clone of the measurement tool.

Related topics

- Section 9.1.2 – IR Viewer object toolbar on page 26
- Section 9.2.1 – IR Viewer object on page 30

10.2.2.10 Deleting measurement tools

Procedure

To delete a measurement tool, do one of the following:

- Select the tool and press DELETE.
- Select the tool, right-click and select **Delete**.

Related topics

- Section 9.1.2 – IR Viewer object toolbar on page 26
- Section 9.2.1 – IR Viewer object on page 30

10.2.2.11 Deleting infrared objects

Procedure

Follow this procedure to delete an infrared object (except Result Table objects):

1	Click anywhere on one of the following: ▪ IR Viewer object ▪ IR Profile object ▪ Digital Photo object
2	On the main toolbar, click .

Related topics

Section 9.2 – Infrared objects on page 30

10.2.2.12 Deleting Result Table objects

Procedure

Follow this procedure to delete a Result Table object:

1	Click anywhere in the Result Table object.
2	On the Microsoft® Word **Table** menu, point to **Delete** and then click **Table** to delete the currently selected table.

Related topics

Section 9.2 – Infrared objects on page 30

10.3 Creating a custom infrared report template based on an existing template

General

The easiest way to create a custom infrared report template is to modify an existing template.

By doing this, you can take advantage of the existing infrared objects already laid out on the report template page and you will save a lot of time compared to creating an infrared report template from scratch.

Procedure

1	Close all open infrared reports.
2	Point to **New** on the **File** menu.
3	Select **New from template**.
4	Select the infrared report template you want to use under the **IR** tab. Make sure you have selected **Template**.
5	Click **OK**.
6	To avoid overwriting the original template, save the template under a different file name before making any changes. When saving it, make sure you save it with the *.dot file name extension.
7	Make your changes in the template according to the following sections: ▪ Section 10.2.1 – About the front & back covers on page 39 ▪ Section 10.2.2 – Creating the infrared report template pages on page 40
8	Save the new infrared report template. When saving it, make sure you save it with the *.dot file name extension.

11 Creating Microsoft® Word document properties

11.1 Creating & editing Microsoft® Word document properties

General

When creating an infrared report, FLIR Reporter extracts the Microsoft® Word *document properties* for the report template and inserts these properties in corresponding *Microsoft® Word fields* in the final report.

You can use these document properties to automate several time-consuming tasks when creating a report. For example, you may want FLIR Reporter to automatically add information such as the name, address and e-mail address of the inspection site, the model name of the camera that you are using, your e-mail address, etc.

Types of document properties

There are two different types of document properties:

- Summary document properties
- Custom document properties

For the former, you can only change the values, but for the latter you can change both the labels and the values.

Procedure

Follow this procedure to create and edit a Microsoft® Word document property:

1	Start Microsoft® Word and then open one of the infrared report templates (*.dot) that are shipped with FLIR Reporter. Users of Microsoft® XP operating systems can find the templates by typing the following path: C:\Documents and Settings\[Your user name]\Application Data\Microsoft\Templates\IR
2	Click **Properties** on the **File** menu. This will display the **Summary** tab of the **Properties** dialog box.
3	Type your information in the appropriate text boxes.
4	Click the **Custom** tab.
5	To *add* a custom property, type a name in the **Name** box. To make your custom properties easy to find, you can type an underscore (_) as the first character in the name of the property.
6	To specify the *type* of property, select **Text**, **Date**, **Number**, or **Yes or No** in the **Type** box.
7	To specify the *value* of the property, type a text in the **Value** box.
8	Click **Add** to add the custom property to the list of properties, and then click **OK**.

9	Save the infrared report template using a different file name but with the same file name extension (*.dot). You have now added summary and custom properties to your renamed infrared report template.

NOTE

- If you want to change the name of a custom document property, due to how the **Custom** tab of the **Properties** dialog box works in Microsoft® Word works there is no other way than deleting it and then recreating it. If you want to move a document property up or down, the whole list has to be re-created.
- You may find that a FLIR Systems property automatically has been added to your document. Do not remove this property. FLIR Reporter uses it to distinguish between infrared documents and other documents.

11.2 Creating a Microsoft® Word field and linking the field to a document property

11.2.1 In Microsoft® Word XP

NOTE This description assumes that you have created summary and custom properties according to section 11.1 – Creating & editing Microsoft® Word document properties on page 54.

Procedure Follow this procedure to create a Microsoft® Word field and link the field to a document property:

1	In your infrared inspection report or report template, put the cursor where you want to insert the field and then click **Field** on the **Insert** menu.
2	Select **DocProperty** in the **Field name** box.
3	Select a property in the **Property** box.
4	Click **OK** to confirm your selection and leave the dialog box.

12 Software reference section

General

Since FLIR Reporter seamlessly integrates with the Microsoft® Word environment, it will be displayed as a menu and additional toolbars, as well as a number of shortcut menus. In this section all menus, submenus, and dialog boxes will be described in detail.

Related topics

- Section 12.1 – FLIR Reporter menu on page 58
- Section 12.2 – Shortcut menu for IR Viewer objects on page 59
- Section 12.4 – Shortcut menu for measurement tools on page 69
- Section 12.5 – Shortcut menu for IR Profile objects on page 73
- Section 12.6 – Shortcut menu for Digital Photo objects on page 77
- Section 12.7 – Shortcut menu for Result table objects on page 78

12.1 FLIR Reporter menu

IR Viewer	Click to insert an IR Viewer object for infrared images and sequence file. An infrared image or sequence file contains valid temperature information that may be output by overlaying different kinds of measurement tools, such as spotmeters, profiles, areas, etc.
IR Profile	Click to insert an IR Profile object. An IR Profile object contains a graph showing pixel values along a line in an infrared image.
Digital Photo	Click to insert a Digital Photo object. This photo may be taken with a stand-alone digital camera, or with the digital visual camera featured on some FLIR Systems infrared cameras. Only use this method to insert a photo when you design a report template. In all other situations, insert photos by clicking **Picture** on the **Insert** menu (**Insert → Picture → From File**).
Insert Table	Click to insert an Result Table object into your current document. A Result Table object displays the results of the measurement tools laid out in the infrared image, as well as other information that is related to the infrared image.
Delete	Click this toolbar button and then click an infrared object to remove the infrared object from your report.
Connect	Click to connect infrared objects to each other—for example, an IR Profile object to an IR Viewer object.
Export document to DB99	Click here to export the document to ThermaCAM™ Database 99. This program is meant for users who wish to bring systematic order to infrared inspection reports produced using FLIR Reporter. The program can also handle old reports produced by earlier versions of FLIR Systems' reporting software. For more information about ThermaCAM™ Database 99, please download the manual from http://flir.custhelp.com
Create PDF Document	Click to create an Adobe® PDF document of the Microsoft® Word document. A free version of Adobe® Reader is available from http://adobe.com/products/acrobat/readstep2.html.
Help	Click to display online help.
Check for updates	Click to check for program updates.
Open Reporter 8 manual	Click to display the user's manual as an Adobe® PDF document.
Select Units	Click to display a dialog box where you can set units.
Select Language	Click to display a dialog box where you can set language.

12.2 Shortcut menu for IR Viewer objects

Note: To display this menu, right-click the object.

Open

To open an image in the IR Viewer, or change the current image to a new image, click **Open**.

Save As

To save the currently displayed image to your hard disk drive, click **Save As**.

Show IR Scale

To show/hide the IR scale at the far right in the infrared image, click **Show IR Scale**.

Zoom

To zoom in on the currently displayed image, click **1**×, **2**×, **4**×, or **8**× on the **Zoom** menu.

Settings

For more information, see section 12.2.1 – Settings dialog box on page 61.

Image Fusion

To display the image fusion dialog box, click **Image Fusion**. In this dialog box you can fuse an infrared image with a digital photo. Fusing images can make it easier to identify the exact position of temperature anomalies.

Follow this procedure to fuse an infrared image with a digital photo:

1	Click **Open IR Image** and select an infrared image.
2	Click **Open Photo** and select the corresponding digital photo.
3	In the infrared image, define the positions of interest by moving the three reference crosshairs to these positions.
4	In the digital photo, move the three reference crosshairs to the corresponding positions.
5	To display the fused image, click **OK**.

In the IR Viewer object you can adjust the exact position of the digital photo in the fused image by doing one or more of the following:

- To move the digital photo up/down or left/right in 1 pixel increments, use the arrow keys on your keyboard.
- To rotate the digital photo clockwise/counter-clockwise in 1° increments, use the Page Up and Page Down keys on your keyboard.

Explanation of additional buttons and controls:

Label	Explanation
View Full Image	To view the full image, click **View Full Image**.
Ref#1	To zoom in on crosshair #1, click **Ref#1**.
Ref#2	To zoom in on crosshair #2, click **Ref#2**.
Ref#3	To zoom in on crosshair #3, click **Ref#3**.

Label	Explanation
Picture in Picture (PiP)	To display the digital photo in its original size, select **Picture in Picture (PiP)**.
Visual image in black and white	To display the digital photo in grayscale, select **Visual image in black and white**.
Open Photo	To open a digital photo, click **Open Photo**.
Threshold	To use one temperature interval for the infrared image and use the digital photo for lower and higher temperatures, select **Threshold** and enter the desired temperature values in the corresponding text boxes. You can adjust the temperature levels by dragging the sliders in the IR Viewer object, once you have closed the dialog box.
Blending	To mix the image from infrared pixels and digital photo pixels, select **Blending**. You can adjust the mixing levels by dragging the sliders in the IR Viewer object, once you have closed the dialog box.

Rotate Left	To rotate the image 90° to the left, click **Rotate Left**.
Rotate Right	To rotate the image 90° to the right, click **Rotate Right**.

12.2.1 Settings dialog box

12.2.1.1 Colors *tab*

Explanation

Label	Explanation
Browse	To open palette files (*.pal) stored at a different location, click **Browse**.
Advanced	To open a dialog box where you can select advanced parameters, click **Advanced**.
Max. Temperature	To define the maximum level temperature of the scale, type a temperature value in the text box.
Min. Temperature	To define the minimum level temperature of the scale, type a temperature value in the text box.
Invert palette	To invert the color distribution in a palette vertically, select this check box.
Show out of range colors	To assign a special color for temperatures outside the calibrated temperature range of the infrared camera, select this check box.
Show saturation colors	To assign a special color for the temperatures outside the scale limits, select this check box.
Use bilinear filtering to enhance image quality	To improve the image quality, select this check box.
Histogram equalization	This is an image-displaying method that evenly distributes the color information over the existing temperatures of the image. This method to distribute the information can be particularly successful when the image contains few peaks of very high temperature values.
Signal linear	This is an image-displaying method where the color information in the image is distributed linear to the signal values of the pixels.
Output linear	This selection works in conjunction with the settings under **Preferred output** on the **Preferences** tab. This is an image-displaying method where you can distribute the colors either according to *temperature* or according to *object signal*.

12.2.1.2 Isotherms *tab*

Explanation

Label	Explanation
Delete	To delete an isotherm, click this button.
Solid	To assign a solid color to an isotherm, select this option button and select a color in the drop-down list box.
Contrast	To assign a contrasting color to an isotherm, select this option button and select a color in the drop-down list box.
Palette	To open a palette and use this palette for the isotherm, select **Palette** and click **Open**.
Max. Temperature	To set the maximum temperature of an isotherm, enter a new value here and click **Apply**. Isotherms may exist outside the temperature range of the current image, which will make the isotherm invisible. By changing the maximum temperature, invisible isotherms can be brought back into range.
Min. Temperature	To set the minimum temperature of an isotherm, enter a new value here and click **Apply**. Isotherms may exist outside the temperature range of the current image, which will make the isotherm invisible. By changing the minimum temperature, invisible isotherms can be brought back into range.
Indoor air temperature	(This text box is only displayed when an insulation alarm is active.) This parameter refers to the air temperature inside the building in question when setting up insulation alarms. An insulation alarm is an alarm that can detect an area where there may be a risk of humidity in a building structure
Outdoor air temperature	(This text box is only displayed when an insulation alarm is active.) This parameter refers to the air temperature outside the building in question when setting up insulation alarms.

Label	Explanation
Insulation factor	(This text box is only displayed when an insulation alarm is active.) The insulation factor is the accepted energy loss through the wall. Different building codes recommend different values, but typical values are 0.70-0.80 for new buildings. **Note:** Refer to your national building code for recommendations.
Atmospheric Temperature	(This text box is only displayed when a humidity alarm is active.) This parameter refers to the atmospheric temperature when setting up humidity alarms. A humidity alarm is an alarm that can detect what may be an insulation deficiency in a wall.
Relative air humidity	(This text box is only displayed when a humidity alarm is active.) This parameter refers to the relative air humidity when setting up humidity alarms.
Humidity Alarm Level	(This text box is only displayed when a humidity alarm is active.) The humidity alarm level is the critical limit of relative humidity that you want to detect in, e.g., a building structure. For example, mold will grow on areas where the relative humidity is less than 100% and you may want to find such areas of interest. **Note:** Refer to your national building code for recommendations.

12.2.1.3 Annotations *tab*

Explanation

Label	Explanation
Label	The label of a text comment. Example: **Label** | **Value** Company | FLIR Systems
Value	The value of a text comment. Example: **Label** | **Value** Company | FLIR Systems
Add	To display a dialog box where you can add a new text comment, click **Add**.
Edit	To display a dialog box where you can change the label and value, click **Edit**.
Delete	To delete the text comment, select the text comment and then click **Delete**.
Image Description	An image description is a brief textual description that is stored inside an image file. It can be created using a Pocket PC and then beamed to the camera using the IrDA communication link. If the image has an image description, the text will be displayed in this edit box. If not, you can add an image description for the image by entering text. The maximum number of characters in an image description is 512.
	Click to listen to a voice comment.
	Click to pause current playback.
	Click to stop current playback.
Sketch	Click to display a dialog box where you can view a freehand sketches that is associated with an image. **Note:** Not all cameras support creating freehand sketches.

12.2.1.4 Object Parameters *tab*

Explanation

Label	Explanation
Emissivity	To change the emissivity, enter a new value and click **Apply**. You can also select a preset emissivity from a table by clicking . For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Reflected apparent temperature	To change the reflected apparent temperature, enter a new value and click **Apply**. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Atmospheric Temperature	To change the atmospheric temperature, enter a new value and click **Apply**. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Relative humidity	To change the relative humidity, enter a new value and click **Apply**. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Distance to object	To change the distance, enter a new value and click **Apply**. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Temperature	To specify the temperature of, *e.g.*, an external lens or heat shield, enter a new value and click **OK** and **Apply**. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Transmission	To specify the transmission of, *e.g.*, an external lens or heat shield, enter a new value and click **OK** and **Apply**. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.

Label	Explanation
Computed transmission	FLIR Reporter can compute the transmission based on atmospheric temperature and relative humidity. Clear the user-defined option button to use the computed transmission. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Fixed transmission	Select this option button, enter a value and click **OK** and **Apply** if you want to use a specific transmission. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Value	To specify the reference temperature, enter a value and click **OK** and **Apply**. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.

12.2.1.5 Preferences *tab*

Explanation

Label	Explanation
Pre-defined measurement symbols and isotherms	If this box is selected all new images will use the analysis symbols and isotherms you set up in the **Settings** dialog box, instead of using the image's own settings from the camera.
Pre-defined palette and color distribution	If his box is selected all new images will use the palette and color distribution you set up in the **Settings** dialog box, instead of using the image's own settings from the camera.
Pre-defined object parameters	If this box is selected all new images will use the object parameters you set up in the **Settings** dialog box, instead of using the image's own settings from the camera.
Scale limits from image	To use the new image's scale limits, select this check box.
Auto-adjust	To autoadjust the image upon importing it, select this check box.
Max. Temperature	To pre-define the scale limit for the new image, enter the maximum temperature level here and click **Apply**.
Min. Temperature	To pre-define the scale limit for the new image, enter the minimum temperature level here and click **Apply**.
Temperature	To output the pixel information as temperature in degrees Kelvin, Celsius, or Fahrenheit, select this option button.
Object signal	To output the pixel information as an object signal, select this option button.

12.3 Shortcut menu for isotherms and IR scales

Note: To display this menu, right-click the object.

Delete	To open delete an isotherm, select **Delete**. **Note:** This menu command is not available when right-clicking IR scales.
Palette	To change the palette, select **Palette**. This will display the **Colors** tab in the **Settings** dialog box. For more information about palettes, see section 12.2.1.1 – Colors tab on page 61.
Isotherm	To change the isotherm, select **Isotherm**. This will display the **Isotherm** tab in the **Settings** dialog box. For more information about isotherms, see section 12.2.1.2 – Isotherms tab on page 62.

12.4 Shortcut menu for measurement tools

Note: To display this menu, right-click the object.

Cursor	Applicable for lines only: Click to create a cursor that you can move along the line.
Delete	To remove the currently selected measurement tool from the infrared image, click **Delete**.
Cold Spot	Applicable for all measurement tools except spotmeter, difference calculation, and marker: To create a spotmeter at the coldest location in the area, click **Cold Spot**.
Hot Spot	Applicable for all measurement tools except spotmeter, delta, and marker: To create a spotmeter at the hottest location in the area, **Hot Spot**.
Settings	For more information, see section 12.4.1 – Settings dialog box on page 70.
Image	This section is identical to section 12.2 – Shortcut menu for IR Viewer objects on page 59.

12.4.1 Settings dialog box

12.4.1.1 General *tab*

Explanation

Label	Explanation
Label	To specify a label (*i.e.* a name appearing in the infrared image) for this measurement tool, enter a name here and click **Apply**.
Show label	To show the label for the measurement tool, select **Show label**.
Show value	To display the value of the measurement tool (*i.e.* the measurement result) in the infrared image, select the value type and click **Apply**. The number of possible value types differs between different measurement tools.
Font size	To specify the font size of the label, select a font size in the **Font size** box and click**Apply**.
Measurement symbol	To specify the color of the symbol for the measurement tool, select a color in the **Measurement symbol** box and click **Apply**.
Text	To specify the color of the label text, select a color in the **Text** box and click **Apply**.
Text background	To specify the color of the background, select a color in the **Text background** box and click **Apply**.
Set as default	To use these settings as default settings for all measurement tools, click **Set as default** and click **Apply**.

12.4.1.2 Object Parameters *tab*

Explanation

Label	Explanation
Custom	To specify custom parameters, select **Custom**, enter new values in the three text boxes and click **Apply**.
Emissivity	To change the emissivity, enter a new value and click **Apply**. You can also select a preset emissivity from a table by clicking . For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Distance to object	To change the distance, enter a new value and click **Apply**. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Reflected apparent temperature	To change the reflected apparent temperature, enter a new value and click **Apply**. For more information about object parameters, see section 15 – Thermographic measurement techniques on page 85.
Set as default	To use these object parameters settings as default settings for all measurement tools, select **Set as default** and click **Apply**.

12.4.1.3 Size/Position *tab*

Explanation

Label	Explanation
X	To change the X-position for a measurement tool, enter a negative or positive value and press **Apply** to move the measurement tool the same number of pixels, relative to its original position.
Y	To change the Y-position for a measurement tool, enter a negative or positive value and press **Apply** to move the measurement tool the same number of pixels, relative to its original position.
Height	To change the height of a measurement tool, enter a value and press **Apply** to specify a new height of the measurement tool.
Width	To change the width of a measurement tool, enter a value and press **Apply** to specify a new width of the measurement tool.
Rotate	To rotate a measurement tool, enter a negative or positive value and press **Apply** to specify a new angle of rotation for the measurement tool.

12.5 Shortcut menu for IR Profile objects

Note: To display this menu, right-click the object.

Grid Lines	To display a grid of horizontal lines in the IR Profile object, click **Grid Lines**.
Legend	To display a legend below the IR Profile object, click **Legend**.
Show Only Visible Profile Lines in Legend	If two or more lines are laid out in the infrared image, clicking **Show Only Visible Profile Lines in Legend** will remove any cleared line results from the legend below the IR Profile object.
3D View	To create a three-dimensional rendering of the graph of the IR Profile object, click **3D View**.
Swap X & Y Axes	To swap the X- and Y-axes of the IR Profile object, click **Swap X & Y Axes**.
Settings	For more information, see section 12.5.1 – Settings dialog box on page 74.

12.5.1 Settings dialog box

12.5.1.1 General *tab*

Explanation

Label	Explanation
Grid Lines	To display a grid of horizontal lines in the IR Profile object, click **Grid Lines**.
Legend	To display a legend below the IR Profile object, click **Legend**.
Show Only Visible Profile Lines in Legend	If two or more lines are laid out in the infrared image, clicking **Show Only Visible Profile Lines in Legend** will remove any cleared line results from the legend below the IR Profile object.
3D View	To create a three-dimensional rendering of the graph of the IR Profile object, click **3D View**.
Swap X & Y Axes	To swap the X- and Y-axes of the IR Profile object, click **Swap X & Y Axes**.
Columns	To add or remove columns in the IR Profile object, select or clear these boxes.
IR Scale	To use the IR scale as the temperature axis, select this option button and click **Apply**.
Auto	To let FLIR Reporter automatically define the temperature axis, select this option button and click **Apply**.
Fixed	To manually define the maximum and minimum axis temperature, select this option button, enter new values and click **Apply**.
Max. Temperature	See above.
Min. Temperature	See above.
Threshold	To display a horizontal line at a certain temperature in the IR Profile object, enter a value in the text box and click **Apply**.

12.5.1.2 Color *tab*

Explanation

Label	Explanation
Background	To change the color of the table background, select a new color from the drop-down list box and click **Apply**.
Plot Area	To change the color of the plot area, select a new color from the drop-down list box and click **Apply**.
Text	To change the color of the table text, select a new color from the drop-down list box and click **Apply**.
Axes	To change the color of the axes, select a new color from the drop-down list box and click **Apply**.
Grid	To change the color of the grid lines, select a new color from the drop-down list box and click **Apply**.

12.5.1.3 Lines *tab*

Explanation To select the line you want to connect the IR Profile object to, select a check box and click **Apply**.

12.6 Shortcut menu for Digital Photo objects

Note: To display this menu, right-click the object.

Open	To open a visual image, click **Open**.

12.7 Shortcut menu for Result table objects

Note: To display this menu, right-click the object.

NOTE	The menu items **Borders and Shading** and **Spelling** will not be described here, since these are standard Microsoft® Word features.
Contents	To select a label and value for a Result Table object, select the label in the left pane and its value in the right pane and click **Apply**.
New feature in version 8.5 SP1	A major new feature in version 8.5 SP1 is the ability to retrieve any existing MeterLink data from an infrared image and display this data in the result table. MeterLink data can be stored in the infrared image by using an external Extech® sensor—such as a clamp meter or a moisture meter—together with the infrared camera. In FLIR Reporter, you can retrieve the MeterLink data from the infrared image by selecting an Extech® sensor in the left pane (e.g., EX845) and then selecting a value in the right pane (e.g., capacitance). For information on how to include MeterLink data in an infrared image when using the camera, refer to the user documentation for one of the following camera series: ▪ FLIR bXX series ▪ FLIR iXX series ▪ FLIR BXXX series ▪ FLIR TXXX series
Refresh	To update the Result Table object, click **Refresh**.

13 Supported file formats in the IR Viewer object

Radiometric file formats

The IR Viewer object supports the following radiometric file formats:

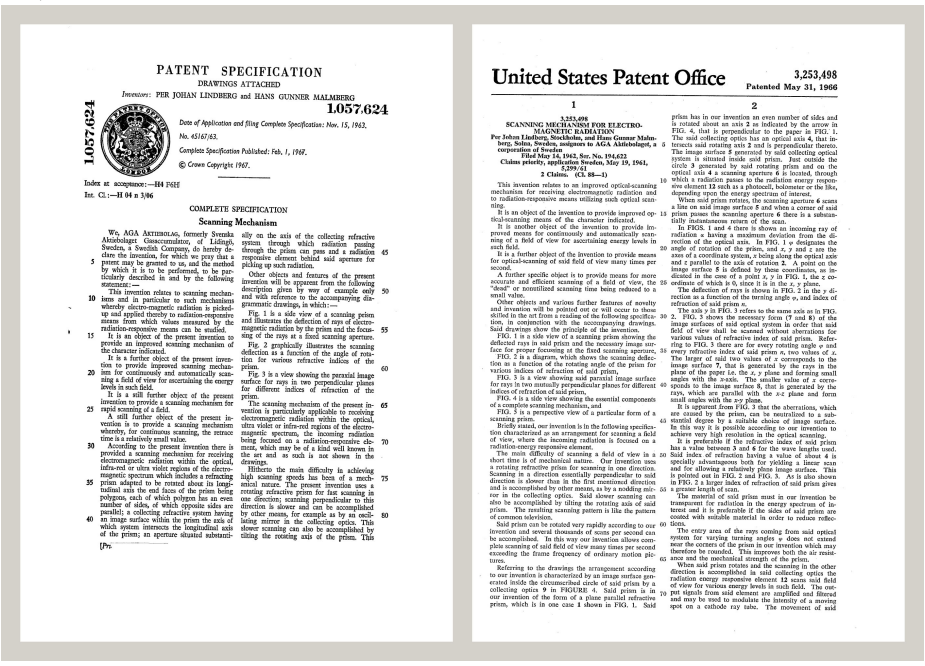
- ThermaCAM™ radiometric *.jpg
- ThermaCAM™ radiometric *.img
- ThermaCAM™ radiometric 8-bit *.tif
- ThermaCAM™ radiometric 8/12-bit *.tif
- ThermaCAM™ radiometric 12-bit *.tif
- ThermoTeknix® *.tgw
- ThermoTeknix® *.tmw
- ThermoTeknix® *.tlw
- ThermaCAM™ radiometric *.seq (radiometric sequence files)

INTENTIONALLY LEFT BLANK

14 About FLIR Systems

FLIR Systems was established in 1978 to pioneer the development of high-performance infrared imaging systems, and is the world leader in the design, manufacture, and marketing of thermal imaging systems for a wide variety of commercial, industrial, and government applications. Today, FLIR Systems embraces five major companies with outstanding achievements in infrared technology since 1958—the Swedish AGEMA Infrared Systems (formerly AGA Infrared Systems), the three United States companies Indigo Systems, FSI, and Inframetrics, and the French company Cedip. In November 2007, Extech Instruments was acquired by FLIR Systems.

T638608;a1



PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventors: PER JOHAN LINDBERG and HANS GUNNER MALMBERG

1,057,624

Date of Application and filing Complete Specification: Nov. 15, 1963.

No. 45167/63.

Complete Specification Published: Feb. 1, 1967.

© Crown Copyright 1967.

Index at acceptance:—H4 [G6F

Int. Cl.:—H 04 n 3/06

COMPLETE SPECIFICATION

Scanning Mechanism

We, AGA AKTIEBOLAG, formerly Svenska Aktiebolaget Gasaccumulator, of Lidingö, Sweden, a Swedish Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to scanning mechanisms and in particular to such mechanisms whereby electro-magnetic radiation is picked-up and applied thereby to radiation-responsive means from which values measured by the radiation-responsive means can be studied.

It is an object of the present invention to provide an improved scanning mechanism of the character indicated.

It is a further object of the present invention to provide improved scanning mechanism for continuously and automatically scanning a field of view for ascertaining the energy levels in such field.

It is a still further object of the present invention to provide a scanning mechanism for rapid scanning of a field.

A still further object of the present invention is to provide a scanning mechanism whereby, for continuous scanning, the retrace time is a relatively small value.

According to the present invention there is provided a scanning mechanism for receiving electromagnetic radiation within the optical, infra-red or ultra violet regions of the electromagnetic spectrum which includes a refracting prism adapted to be rotated about its longitudinal axis the end faces of the prism being polygons, each of which polygon has an even number of sides, of which opposite sides are parallel; a collecting refractive system having an image surface within the prism the axis of which system intersects the longitudinal axis of the prism; an aperture situated substantially on the axis of the collecting refractive system through which radiation passing through the prism can pass and a radiation responsive element behind said aperture for picking up such radiation.

Other objects and features of the present invention will be apparent from the following description given by way of example only and with reference to the accompanying diagrammatic drawings, in which:—

Fig. 1 is a side view of a scanning prism and illustrates the deflection of rays of electromagnetic radiation by the prism and the focussing of the rays at a fixed scanning aperture.

Fig. 2 graphically illustrates the scanning deflection as a function of the angle of rotation for various refractive indices of the prism.

Fig. 3 is a view showing the paraxial image surface for rays in two perpendicular planes for different indices of refraction of the prism.

The scanning mechanism of the present invention is particularly applicable to receiving electromagnetic radiation within the optical, ultra violet or infra-red regions of the electromagnetic spectrum, the incoming radiation being focused on a radiation-responsive element, which may be of a kind well known in the art and as such is not shown in the drawings.

Hitherto the main difficulty in achieving high scanning speeds has been of a mechanical nature. The present invention uses a rotating refractive prism for fast scanning in one direction; scanning perpendicular to this direction is slower and can be accomplished by other means, for example as by an oscillating mirror in the collecting optics. This slower scanning can also be accomplished by tilting the rotating axis of the prism. This

[Pr

United States Patent Office

3,253,498

Patented May 31, 1966

1

3,253,498

SCANNING MECHANISM FOR ELECTROMAGNETIC RADIATION

Per Johan Lindberg, Stockholm, and Hans Gunnar Malmberg, Solna, Sweden, assignors to AGA Aktiebolaget, a corporation of Sweden

Filed May 14, 1962, Ser. No. 194,622

Claims priority, application Sweden, May 19, 1961, 5,299/61

2 Claims. (Cl. 88—1)

This invention relates to an improved optical-scanning mechanism for scanning electromagnetic radiation and to radiation-responsive means utilizing such optical scanning.

It is an object of the invention to provide improved means for continuously and automatically scanning of a field of view for ascertaining energy levels in such field.

It is a further object of the invention to provide means for optical-scanning of said field of view many times per second.

A further specific object is to provide means for more accurate and efficient scanning of a field of view, the "dead" or nonutilized scanning time being reduced to a small value.

Other objects and various further features of novelty and invention will be pointed out or will occur to those skilled in the art from a reading of the following specification, in conjunction with the accompanying drawings. Said drawings show the principle of the invention.

FIG. 1 is a side view of a scanning prism showing the deflected rays in said prism and the necessary image surface for proper focussing at the fixed scanning aperture.

FIG. 2 is a diagram, which shows the scanning deflection as a function of the rotating angle of the prism for various indices of refraction of said prism,

FIG. 3 is a view showing said paraxial image surface for rays in two mutually perpendicular planes for different indices of refraction of said prism,

FIG. 4 is a side view showing the essential components of a complete scanning mechanism, and

FIG. 5 is a perspective view of a particular form of a scanning prism.

Briefly stated, our invention is in the following specification characterized as an arrangement for scanning a field of view, where the incoming radiation is focused on a radiation-energy responsive element.

The main difficulty of scanning a field of view in a short time is of mechanical nature. Our invention uses a rotating refractive prism for scanning in one direction. Scanning in a direction essentially perpendicular to said direction is slower than in the first mentioned direction and is accomplished by other means, as by a nodding mirror in the collecting optics. Said slower scanning can also be accomplished by tilting the rotating axis of said prism. The resulting scanning pattern is like the pattern of common television.

Said prism can be rotated very rapidly according to our invention and several thousands of scans per second can be accomplished. In this way our invention allows complete scanning of said field of view many times per second exceeding the frame frequency of ordinary motion pictures.

Referring to the drawings the arrangement according to our invention is characterized by an image surface generated inside the circumscribed circle of said prism by a collecting optics 9 in FIGURE 4. Said prism is in our invention of the form of a plane parallel refractive prism, which is in one case 1 shown in FIG. 1. Said

2

prism has in our invention an even number of sides and is rotated about an axis 2 as indicated by the arrow in FIG. 4, that is perpendicular to the paper in FIG. 1. The said collecting optics has an optical axis 4, that intersects said rotating axis 2 and is perpendicular thereto. The image surface 8 generated by said collecting optical system is situated inside said prism. Just outside the circle 3 generated by said rotating prism and on the optical axis 4 a scanning aperture 6 is located, through which a radiation passes to the radiation energy responsive element 12 such as a photocell, bolometer or the like, depending upon the energy spectrum of interest.

When said prism rotates, the scanning aperture 6 scans a line on said image surface 8 and when a corner of said prism passes the scanning aperture 6 there is a substantially instantaneous return of the scan.

In FIGS. 1 and 4 there is shown an incoming ray of radiation 4 having a maximum deviation from the direction of the optical axis. In FIG. 1 α designates the angle of rotation of the prism, and x, y and z are the axes of a coordinate system, x being along the optical axis and z parallel to the axis of rotation 2. A point on the image surface 8 for each value of these angles is indicated in the case of a point x, y, z = 0, the z coordinate of which is 0, since it is in the x, y plane.

The deflection of rays is shown in FIG. 2 in the y direction as a function of the turning angle, α, and index of refraction of said prism n.

The axis y in FIG. 3 refers to the same axis as in FIG. 2. FIG. 3 shows the necessary focus ($\bar{x}$ and $\bar{z}$) of the image surfaces of said optical system in order that said field of view shall be scanned without aberrations for various values of refractive index of said prism. Referring to FIG. 3 there are for every rotating angle α and every refractive index of said prism n, two values of x. The larger of said two values of x corresponds to the image surface 7, that is generated by the rays in the plane of the paper i.e. the x, y plane and forming small angles with the x-axis. The smaller value of x corresponds to the image surface 8, that is generated by the rays, which are parallel with the x-z plane and form small angles with the x-y plane.

It is apparent from FIG. 3 that the aberrations, which are caused by the prism, can be neutralized to a substantial degree by a suitable choice of image surface. In this way it is possible according to our invention to achieve very high resolution in the optical scanning.

It is preferable if the refractive index of said prism has a value between 3 and 6 for the wave lengths used. Said index of refraction having a value of about 4 is specially advantageous both for yielding a linear scan and for allowing a relatively plane image surface. This is pointed out in FIG. 2 and FIG. 3. As is also shown in FIG. 2 a large index of refraction of said prism gives a greater length of scan.

The material of said prism must in our invention be transparent for radiation in the energy spectrum of interest and it is preferable if the sides of said prism are coated with suitable material in order to reduce reflections.

The entry area of the rays coming from said optical system for varying turning angles α does not extend near the corners of the prism in our invention which may therefore be rounded. This improves both the air resistance and the mechanical strength of the prism.

When said prism rotates and the scanning in the other direction is accomplished in said collecting optics the radiation energy responsive element 12 scans said field of view for various energy levels in such field. The output signals from said element are amplified and filtered and may be used to modulate the intensity of a moving spot on a cathode ray tube. The movement of said

Figure 14.1 Patent documents from the early 1960s

The company has sold more than 100,000 infrared cameras worldwide for applications such as predictive maintenance, R & D, non-destructive testing, process control and automation, and machine vision, among many others.

FLIR Systems has three manufacturing plants in the United States (Portland, OR, Boston, MA, Santa Barbara, CA) and one in Sweden (Stockholm). Since 2007 there is also a manufacturing plant in Tallinn, Estonia. Direct sales offices in Belgium, Brazil,

China, France, Germany, Great Britain, Hong Kong, Italy, Japan, Korea, Sweden, and the USA—together with a worldwide network of agents and distributors—support our international customer base.

FLIR Systems is at the forefront of innovation in the infrared camera industry. We anticipate market demand by constantly improving our existing cameras and developing new ones. The company has set milestones in product design and development such as the introduction of the first battery-operated portable camera for industrial inspections, and the first uncooled infrared camera, to mention just two innovations.

10722703;a2

Figure 14.2 LEFT: Thermovision® Model 661 from 1969. The camera weighed approximately 25 kg (55 lb.), the oscilloscope 20 kg (44 lb.), and the tripod 15 kg (33 lb.). The operator also needed a 220 VAC generator set, and a 10 L (2.6 US gallon) jar with liquid nitrogen. To the left of the oscilloscope the Polaroid attachment (6 kg/13 lb.) can be seen. **RIGHT:** FLIR i7 from 2009. Weight: 0.34 kg (0.75 lb.), including the battery.

FLIR Systems manufactures all vital mechanical and electronic components of the camera systems itself. From detector design and manufacturing, to lenses and system electronics, to final testing and calibration, all production steps are carried out and supervised by our own engineers. The in-depth expertise of these infrared specialists ensures the accuracy and reliability of all vital components that are assembled into your infrared camera.

14.1 More than just an infrared camera

At FLIR Systems we recognize that our job is to go beyond just producing the best infrared camera systems. We are committed to enabling all users of our infrared camera systems to work more productively by providing them with the most powerful

camera–software combination. Especially tailored software for predictive maintenance, R & D, and process monitoring is developed in-house. Most software is available in a wide variety of languages.

We support all our infrared cameras with a wide variety of accessories to adapt your equipment to the most demanding infrared applications.

14.2 Sharing our knowledge

Although our cameras are designed to be very user-friendly, there is a lot more to thermography than just knowing how to handle a camera. Therefore, FLIR Systems has founded the Infrared Training Center (ITC), a separate business unit, that provides certified training courses. Attending one of the ITC courses will give you a truly hands-on learning experience.

The staff of the ITC are also there to provide you with any application support you may need in putting infrared theory into practice.

14.3 Supporting our customers

FLIR Systems operates a worldwide service network to keep your camera running at all times. If you discover a problem with your camera, local service centers have all the equipment and expertise to solve it within the shortest possible time. Therefore, there is no need to send your camera to the other side of the world or to talk to someone who does not speak your language.

14.4 A few images from our facilities

10401303;a1

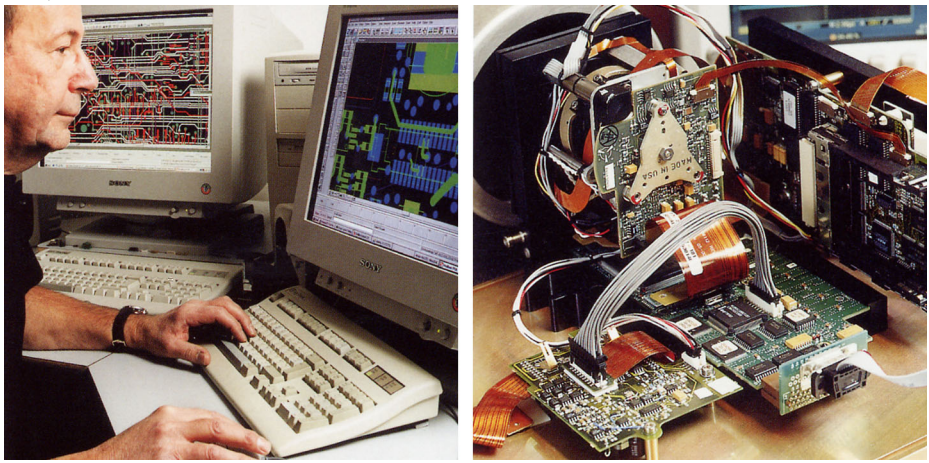


Figure 14.3 LEFT: Development of system electronics; **RIGHT:** Testing of an FPA detector

10401403;a1

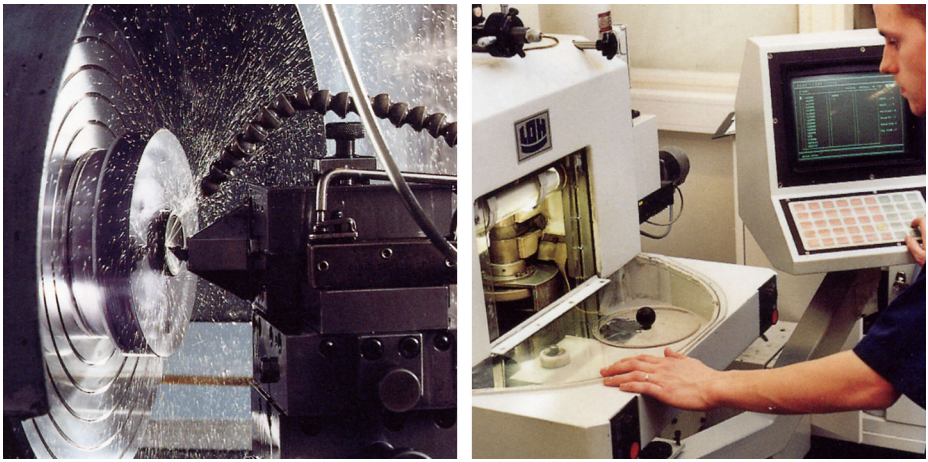


Figure 14.4 LEFT: Diamond turning machine; **RIGHT:** Lens polishing

10401503;a1

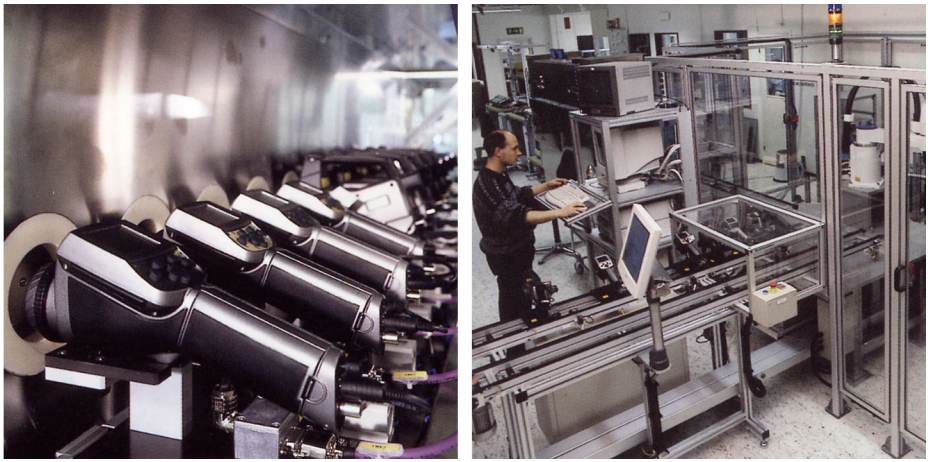


Figure 14.5 LEFT: Testing of infrared cameras in the climatic chamber; **RIGHT:** Robot used for camera testing and calibration

15 Thermographic measurement techniques

15.1 Introduction

An infrared camera measures and images the emitted infrared radiation from an object. The fact that radiation is a function of object surface temperature makes it possible for the camera to calculate and display this temperature.

However, the radiation measured by the camera does not only depend on the temperature of the object but is also a function of the emissivity. Radiation also originates from the surroundings and is reflected in the object. The radiation from the object and the reflected radiation will also be influenced by the absorption of the atmosphere.

To measure temperature accurately, it is therefore necessary to compensate for the effects of a number of different radiation sources. This is done on-line automatically by the camera. The following object parameters must, however, be supplied for the camera:

- The emissivity of the object
- The reflected apparent temperature
- The distance between the object and the camera
- The relative humidity
- Temperature of the atmosphere

15.2 Emissivity

The most important object parameter to set correctly is the emissivity which, in short, is a measure of how much radiation is emitted from the object, compared to that from a perfect blackbody of the same temperature.

Normally, object materials and surface treatments exhibit emissivity ranging from approximately 0.1 to 0.95. A highly polished (mirror) surface falls below 0.1, while an oxidized or painted surface has a higher emissivity. Oil-based paint, regardless of color in the visible spectrum, has an emissivity over 0.9 in the infrared. Human skin exhibits an emissivity 0.97 to 0.98.

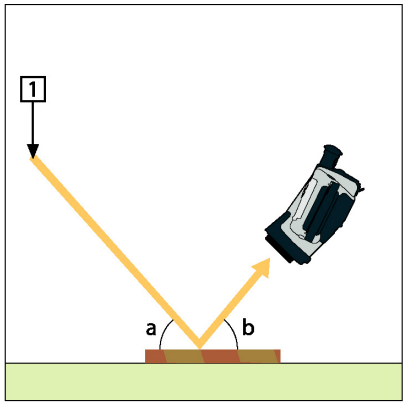
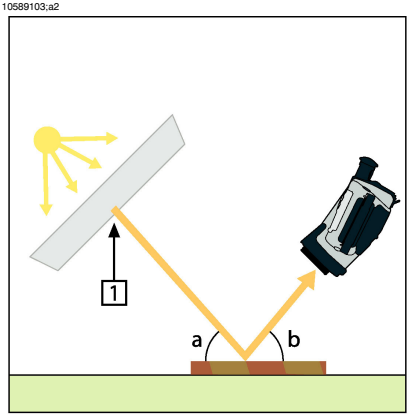
Non-oxidized metals represent an extreme case of perfect opacity and high reflexivity, which does not vary greatly with wavelength. Consequently, the emissivity of metals is low – only increasing with temperature. For non-metals, emissivity tends to be high, and decreases with temperature.

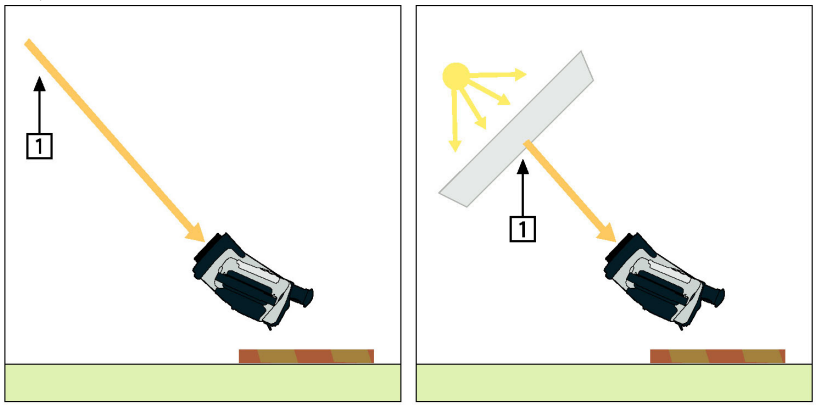
15.2.1 Finding the emissivity of a sample

15.2.1.1 Step 1: Determining reflected apparent temperature

Use one of the following two methods to determine reflected apparent temperature:

15.2.1.1.1 Method 1: Direct method

1	Look for possible reflection sources, considering that the incident angle = reflection angle (a = b). 10588903;a1  **Figure 15.1** 1 = Reflection source
2	If the reflection source is a spot source, modify the source by obstructing it using a piece if cardboard. 10589103;a2  **Figure 15.2** 1 = Reflection source

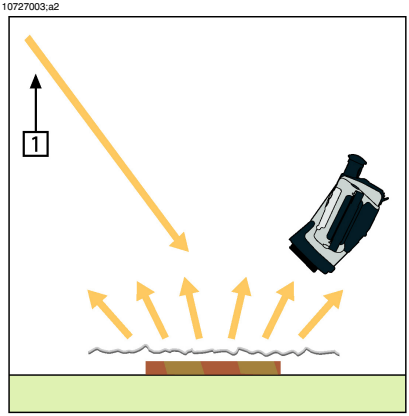
3	Measure the radiation intensity (= apparent temperature) from the reflecting source using the following settings: ▪ Emissivity: 1.0 ▪ D_{obj}: 0 You can measure the radiation intensity using one of the following two methods: 10589003;a2  **Figure 15.3** 1 = Reflection source

Note: Using a thermocouple to measure reflected apparent temperature is not recommended for two important reasons:

- A thermocouple does not measure radiation intensity
- A thermocouple requires a very good thermal contact to the surface, usually by gluing and covering the sensor by a thermal isolator.

15.2.1.1.2 Method 2: Reflector method

1	Crumble up a large piece of aluminum foil.
2	Uncrumble the aluminum foil and attach it to a piece of cardboard of the same size.
3	Put the piece of cardboard in front of the object you want to measure. Make sure that the side with aluminum foil points to the camera.
4	Set the emissivity to 1.0.

5	Measure the apparent temperature of the aluminum foil and write it down. 10727003;a2  **Figure 15.4** Measuring the apparent temperature of the aluminum foil

15.2.1.2 Step 2: Determining the emissivity

1	Select a place to put the sample.
2	Determine and set reflected apparent temperature according to the previous procedure.
3	Put a piece of electrical tape with known high emissivity on the sample.
4	Heat the sample at least 20 K above room temperature. Heating must be reasonably even.
5	Focus and auto-adjust the camera, and freeze the image.
6	Adjust **Level** and **Span** for best image brightness and contrast.
7	Set emissivity to that of the tape (usually 0.97).
8	Measure the temperature of the tape using one of the following measurement functions: ▪ **Isotherm** (helps you to determine both the temperature and how evenly you have heated the sample) ▪ **Spot** (simpler) ▪ **Box Avg** (good for surfaces with varying emissivity).
9	Write down the temperature.
10	Move your measurement function to the sample surface.
11	Change the emissivity setting until you read the same temperature as your previous measurement.
12	Write down the emissivity.

Note:

- Avoid forced convection
- Look for a thermally stable surrounding that will not generate spot reflections
- Use high quality tape that you know is not transparent, and has a high emissivity you are certain of
- This method assumes that the temperature of your tape and the sample surface are the same. If they are not, your emissivity measurement will be wrong.

15.3 Reflected apparent temperature

This parameter is used to compensate for the radiation reflected in the object. If the emissivity is low and the object temperature relatively far from that of the reflected it will be important to set and compensate for the reflected apparent temperature correctly.

15.4 Distance

The distance is the distance between the object and the front lens of the camera. This parameter is used to compensate for the following two facts:

- That radiation from the target is absorbed by the athmosphere between the object and the camera.
- That radiation from the atmosphere itself is detected by the camera.

15.5 Relative humidity

The camera can also compensate for the fact that the transmittance is also dependent on the relative humidity of the atmosphere. To do this set the relative humidity to the correct value. For short distances and normal humidity the relative humidity can normally be left at a default value of 50%.

15.6 Other parameters

In addition, some cameras and analysis programs from FLIR Systems allow you to compensate for the following parameters:

- Atmospheric temperature – *i.e.* the temperature of the atmosphere between the camera and the target
- External optics temperature – *i.e.* the temperature of any external lenses or windows used in front of the camera
- External optics transmittance – *i.e.* the transmission of any external lenses or windows used in front of the camera

INTENTIONALLY LEFT BLANK

16 History of infrared technology

Before the year 1800, the existence of the infrared portion of the electromagnetic spectrum wasn't even suspected. The original significance of the infrared spectrum, or simply ‘the infrared’ as it is often called, as a form of heat radiation is perhaps less obvious today than it was at the time of its discovery by Herschel in 1800.

10398703;a1

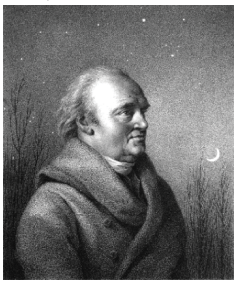


Figure 16.1 Sir William Herschel (1738–1822)

The discovery was made accidentally during the search for a new optical material. Sir William Herschel – Royal Astronomer to King George III of England, and already famous for his discovery of the planet Uranus – was searching for an optical filter material to reduce the brightness of the sun’s image in telescopes during solar observations. While testing different samples of colored glass which gave similar reductions in brightness he was intrigued to find that some of the samples passed very little of the sun’s heat, while others passed so much heat that he risked eye damage after only a few seconds’ observation.

Herschel was soon convinced of the necessity of setting up a systematic experiment, with the objective of finding a single material that would give the desired reduction in brightness as well as the maximum reduction in heat. He began the experiment by actually repeating Newton’s prism experiment, but looking for the heating effect rather than the visual distribution of intensity in the spectrum. He first blackened the bulb of a sensitive mercury-in-glass thermometer with ink, and with this as his radiation detector he proceeded to test the heating effect of the various colors of the spectrum formed on the top of a table by passing sunlight through a glass prism. Other thermometers, placed outside the sun’s rays, served as controls.

As the blackened thermometer was moved slowly along the colors of the spectrum, the temperature readings showed a steady increase from the violet end to the red end. This was not entirely unexpected, since the Italian researcher, Landriani, in a similar experiment in 1777 had observed much the same effect. It was Herschel,

however, who was the first to recognize that there must be a point where the heating effect reaches a maximum, and that measurements confined to the visible portion of the spectrum failed to locate this point.

10398903;a1

Figure 16.2 Marsilio Landriani (1746–1815)

Moving the thermometer into the dark region beyond the red end of the spectrum, Herschel confirmed that the heating continued to increase. The maximum point, when he found it, lay well beyond the red end – in what is known today as the 'infrared wavelengths'.

When Herschel revealed his discovery, he referred to this new portion of the electromagnetic spectrum as the 'thermometrical spectrum'. The radiation itself he sometimes referred to as 'dark heat', or simply 'the invisible rays'. Ironically, and contrary to popular opinion, it wasn't Herschel who originated the term 'infrared'. The word only began to appear in print around 75 years later, and it is still unclear who should receive credit as the originator.

Herschel's use of glass in the prism of his original experiment led to some early controversies with his contemporaries about the actual existence of the infrared wavelengths. Different investigators, in attempting to confirm his work, used various types of glass indiscriminately, having different transparencies in the infrared. Through his later experiments, Herschel was aware of the limited transparency of glass to the newly-discovered thermal radiation, and he was forced to conclude that optics for the infrared would probably be doomed to the use of reflective elements exclusively (i.e. plane and curved mirrors). Fortunately, this proved to be true only until 1830, when the Italian investigator, Melloni, made his great discovery that naturally occurring rock salt (NaCl) – which was available in large enough natural crystals to be made into lenses and prisms – is remarkably transparent to the infrared. The result was that rock salt became the principal infrared optical material, and remained so for the next hundred years, until the art of synthetic crystal growing was mastered in the 1930's.

10399103;a1

Figure 16.3 Macedonio Melloni (1798–1854)

Thermometers, as radiation detectors, remained unchallenged until 1829, the year Nobili invented the thermocouple. (Herschel's own thermometer could be read to 0.2 °C (0.036 °F), and later models were able to be read to 0.05 °C (0.09 °F)). Then a breakthrough occurred; Melloni connected a number of thermocouples in series to form the first thermopile. The new device was at least 40 times as sensitive as the best thermometer of the day for detecting heat radiation – capable of detecting the heat from a person standing three meters away.

The first so-called 'heat-picture' became possible in 1840, the result of work by Sir John Herschel, son of the discoverer of the infrared and a famous astronomer in his own right. Based upon the differential evaporation of a thin film of oil when exposed to a heat pattern focused upon it, the thermal image could be seen by reflected light where the interference effects of the oil film made the image visible to the eye. Sir John also managed to obtain a primitive record of the thermal image on paper, which he called a 'thermograph'.

10399003;a2

Figure 16.4 Samuel P. Langley (1834–1906)

The improvement of infrared-detector sensitivity progressed slowly. Another major breakthrough, made by Langley in 1880, was the invention of the bolometer. This consisted of a thin blackened strip of platinum connected in one arm of a Wheatstone bridge circuit upon which the infrared radiation was focused and to which a sensitive galvanometer responded. This instrument is said to have been able to detect the heat from a cow at a distance of 400 meters.

An English scientist, Sir James Dewar, first introduced the use of liquefied gases as cooling agents (such as liquid nitrogen with a temperature of -196 °C (-320.8 °F)) in low temperature research. In 1892 he invented a unique vacuum insulating container in which it is possible to store liquefied gases for entire days. The common 'thermos bottle', used for storing hot and cold drinks, is based upon his invention.

Between the years 1900 and 1920, the inventors of the world 'discovered' the infrared. Many patents were issued for devices to detect personnel, artillery, aircraft, ships – and even icebergs. The first operating systems, in the modern sense, began to be developed during the 1914–18 war, when both sides had research programs devoted to the military exploitation of the infrared. These programs included experimental systems for enemy intrusion/detection, remote temperature sensing, secure communications, and 'flying torpedo' guidance. An infrared search system tested during this period was able to detect an approaching airplane at a distance of 1.5 km (0.94 miles), or a person more than 300 meters (984 ft.) away.

The most sensitive systems up to this time were all based upon variations of the bolometer idea, but the period between the two wars saw the development of two revolutionary new infrared detectors: the image converter and the photon detector. At first, the image converter received the greatest attention by the military, because it enabled an observer for the first time in history to literally 'see in the dark'. However, the sensitivity of the image converter was limited to the near infrared wavelengths, and the most interesting military targets (i.e. enemy soldiers) had to be illuminated by infrared search beams. Since this involved the risk of giving away the observer's position to a similarly-equipped enemy observer, it is understandable that military interest in the image converter eventually faded.

The tactical military disadvantages of so-called 'active' (i.e. search beam-equipped) thermal imaging systems provided impetus following the 1939–45 war for extensive secret military infrared-research programs into the possibilities of developing 'passive' (no search beam) systems around the extremely sensitive photon detector. During this period, military secrecy regulations completely prevented disclosure of the status of infrared-imaging technology. This secrecy only began to be lifted in the middle of the 1950's, and from that time adequate thermal-imaging devices finally began to be available to civilian science and industry.

17 Theory of thermography

17.1 Introduction

The subjects of infrared radiation and the related technique of thermography are still new to many who will use an infrared camera. In this section the theory behind thermography will be given.

17.2 The electromagnetic spectrum

The electromagnetic spectrum is divided arbitrarily into a number of wavelength regions, called *bands*, distinguished by the methods used to produce and detect the radiation. There is no fundamental difference between radiation in the different bands of the electromagnetic spectrum. They are all governed by the same laws and the only differences are those due to differences in wavelength.

10067803;a1

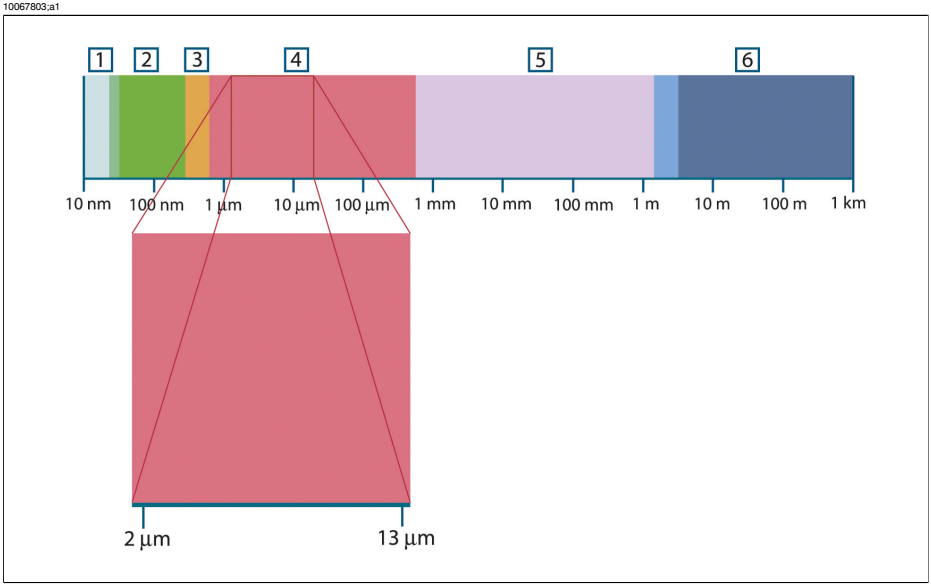


Figure 17.1 The electromagnetic spectrum. **1:** X-ray; **2:** UV; **3:** Visible; **4:** IR; **5:** Microwaves; **6:** Radiowaves.

Thermography makes use of the infrared spectral band. At the short-wavelength end the boundary lies at the limit of visual perception, in the deep red. At the long-wavelength end it merges with the microwave radio wavelengths, in the millimeter range.

The infrared band is often further subdivided into four smaller bands, the boundaries of which are also arbitrarily chosen. They include: the *near infrared* (0.75–3 µm), the *middle infrared* (3–6 µm), the *far infrared* (6–15 µm) and the *extreme infrared* (15–100

µm). Although the wavelengths are given in µm (micrometers), other units are often still used to measure wavelength in this spectral region, *e.g.* nanometer (nm) and Ångström (Å).

The relationships between the different wavelength measurements is:

$$10\ 000\ \text{Å} = 1\ 000\ \text{nm} = 1\ \mu = 1\ \mu\text{m}$$

17.3 Blackbody radiation

A blackbody is defined as an object which absorbs all radiation that impinges on it at any wavelength. The apparent misnomer *black* relating to an object emitting radiation is explained by Kirchhoff's Law (after *Gustav Robert Kirchhoff*, 1824–1887), which states that a body capable of absorbing all radiation at any wavelength is equally capable in the emission of radiation.

10398803;a1

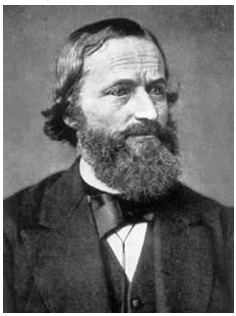


Figure 17.2 Gustav Robert Kirchhoff (1824–1887)

The construction of a blackbody source is, in principle, very simple. The radiation characteristics of an aperture in an isotherm cavity made of an opaque absorbing material represents almost exactly the properties of a blackbody. A practical application of the principle to the construction of a perfect absorber of radiation consists of a box that is light tight except for an aperture in one of the sides. Any radiation which then enters the hole is scattered and absorbed by repeated reflections so only an infinitesimal fraction can possibly escape. The blackness which is obtained at the aperture is nearly equal to a blackbody and almost perfect for all wavelengths.

By providing such an isothermal cavity with a suitable heater it becomes what is termed a *cavity radiator*. An isothermal cavity heated to a uniform temperature generates blackbody radiation, the characteristics of which are determined solely by the temperature of the cavity. Such cavity radiators are commonly used as sources of radiation in temperature reference standards in the laboratory for calibrating thermographic instruments, such as a FLIR Systems camera for example.

If the temperature of blackbody radiation increases to more than 525°C (977°F), the source begins to be visible so that it appears to the eye no longer black. This is the incipient red heat temperature of the radiator, which then becomes orange or yellow as the temperature increases further. In fact, the definition of the so-called *color temperature* of an object is the temperature to which a blackbody would have to be heated to have the same appearance.

Now consider three expressions that describe the radiation emitted from a blackbody.

17.3.1 Planck's law

10399203;a1

Figure 17.3 Max Planck (1858–1947)

Max Planck (1858–1947) was able to describe the spectral distribution of the radiation from a blackbody by means of the following formula:

$$W_{\lambda b} = \frac{2\pi hc^2}{\lambda^5\left(e^{hc/\lambda kT} - 1\right)} \times 10^{-6}[Watt/m^2, \mu m]$$

where:

$W_{\lambda b}$	Blackbody spectral radiant emittance at wavelength λ.
c	Velocity of light = 3×10^8 m/s
h	Planck's constant = 6.6×10^{-34} Joule sec.
k	Boltzmann's constant = 1.4×10^{-23} Joule/K.
T	Absolute temperature (K) of a blackbody.
λ	Wavelength (μm).

➲ The factor 10^{-6} is used since spectral emittance in the curves is expressed in Watt/m^2, µm.

17

Planck's formula, when plotted graphically for various temperatures, produces a family of curves. Following any particular Planck curve, the spectral emittance is zero at $\lambda = 0$, then increases rapidly to a maximum at a wavelength λ_{max} and after passing it approaches zero again at very long wavelengths. The higher the temperature, the shorter the wavelength at which maximum occurs.

10327103;a4

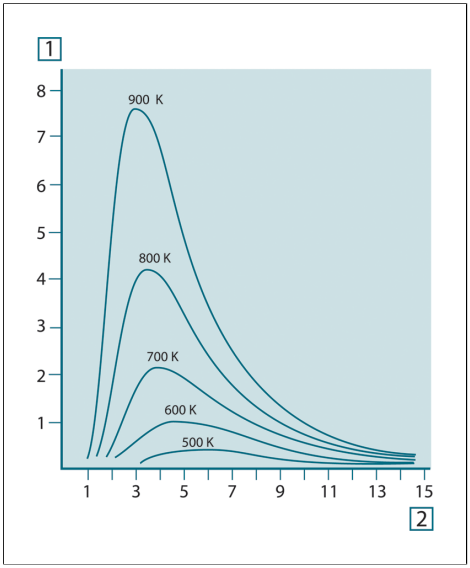


Figure 17.4 Blackbody spectral radiant emittance according to Planck's law, plotted for various absolute temperatures. **1:** Spectral radiant emittance (W/cm^2 × 10^3(µm)); **2:** Wavelength (µm)

17.3.2 Wien's displacement law

By differentiating Planck's formula with respect to λ, and finding the maximum, we have:

$$\lambda_{\max} = \frac{2898}{T}[\mu m]$$

This is Wien's formula (after *Wilhelm Wien*, 1864–1928), which expresses mathematically the common observation that colors vary from red to orange or yellow as the temperature of a thermal radiator increases. The wavelength of the color is the same as the wavelength calculated for λ_{max}. A good approximation of the value of λ_{max} for a given blackbody temperature is obtained by applying the rule-of-thumb 3 000/T

μm. Thus, a very hot star such as Sirius (11 000 K), emitting bluish-white light, radiates with the peak of spectral radiant emittance occurring within the invisible ultraviolet spectrum, at wavelength 0.27 μm.

10399403;a1

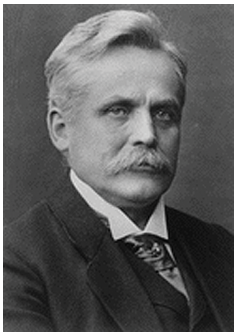


Figure 17.5 Wilhelm Wien (1864–1928)

The sun (approx. 6 000 K) emits yellow light, peaking at about 0.5 μm in the middle of the visible light spectrum.

At room temperature (300 K) the peak of radiant emittance lies at 9.7 μm, in the far infrared, while at the temperature of liquid nitrogen (77 K) the maximum of the almost insignificant amount of radiant emittance occurs at 38 μm, in the extreme infrared wavelengths.

10327203;a4

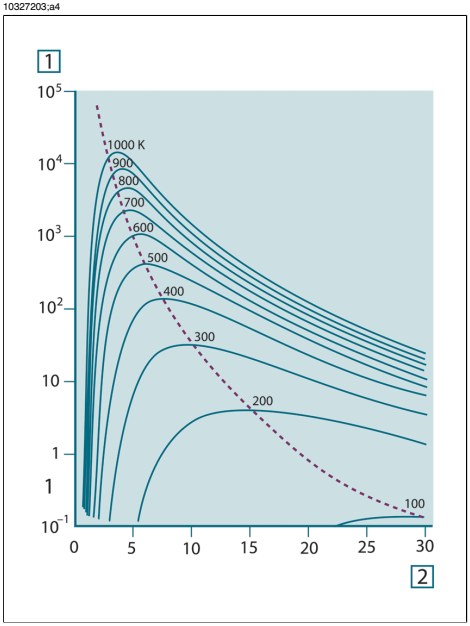


Figure 17.6 Planckian curves plotted on semi-log scales from 100 K to 1000 K. The dotted line represents the locus of maximum radiant emittance at each temperature as described by Wien's displacement law. **1:** Spectral radiant emittance (W/cm^2 (µm)); **2:** Wavelength (µm).

17.3.3 Stefan-Boltzmann's law

By integrating Planck's formula from $\lambda = 0$ to $\lambda = \infty$, we obtain the total radiant emittance (W_b) of a blackbody:

$$W_b = \sigma T^4 \ [\mathrm{Watt/m^2}]$$

This is the Stefan-Boltzmann formula (after *Josef Stefan*, 1835–1893, and *Ludwig Boltzmann*, 1844–1906), which states that the total emissive power of a blackbody is proportional to the fourth power of its absolute temperature. Graphically, W_b represents the area below the Planck curve for a particular temperature. It can be shown that the radiant emittance in the interval $\lambda = 0$ to λ_{max} is only 25% of the total, which represents about the amount of the sun's radiation which lies inside the visible light spectrum.

10399303;a1

Figure 17.7 Josef Stefan (1835–1893), and Ludwig Boltzmann (1844–1906)

Using the Stefan-Boltzmann formula to calculate the power radiated by the human body, at a temperature of 300 K and an external surface area of approx. 2 m^2, we obtain 1 kW. This power loss could not be sustained if it were not for the compensating absorption of radiation from surrounding surfaces, at room temperatures which do not vary too drastically from the temperature of the body – or, of course, the addition of clothing.

17.3.4 Non-blackbody emitters

So far, only blackbody radiators and blackbody radiation have been discussed. However, real objects almost never comply with these laws over an extended wavelength region – although they may approach the blackbody behavior in certain spectral intervals. For example, a certain type of white paint may appear perfectly *white* in the visible light spectrum, but becomes distinctly *gray* at about 2 µm, and beyond 3 µm it is almost *black*.

There are three processes which can occur that prevent a real object from acting like a blackbody: a fraction of the incident radiation α may be absorbed, a fraction ρ may be reflected, and a fraction τ may be transmitted. Since all of these factors are more or less wavelength dependent, the subscript λ is used to imply the spectral dependence of their definitions. Thus:

- The spectral absorptance α_λ = the ratio of the spectral radiant power absorbed by an object to that incident upon it.
- The spectral reflectance ρ_λ = the ratio of the spectral radiant power reflected by an object to that incident upon it.
- The spectral transmittance τ_λ = the ratio of the spectral radiant power transmitted through an object to that incident upon it.

The sum of these three factors must always add up to the whole at any wavelength, so we have the relation:

$$\alpha_\lambda + \rho_\lambda + \tau_\lambda = 1$$

For opaque materials $\tau_\lambda = 0$ and the relation simplifies to:

$$\alpha_\lambda + \rho_\lambda = 1$$

17

Another factor, called the emissivity, is required to describe the fraction ε of the radiant emittance of a blackbody produced by an object at a specific temperature. Thus, we have the definition:

The spectral emissivity ε_λ= the ratio of the spectral radiant power from an object to that from a blackbody at the same temperature and wavelength.

Expressed mathematically, this can be written as the ratio of the spectral emittance of the object to that of a blackbody as follows:

$$\varepsilon_\lambda = \frac{W_{\lambda o}}{W_{\lambda b}}$$

Generally speaking, there are three types of radiation source, distinguished by the ways in which the spectral emittance of each varies with wavelength.

- A blackbody, for which $\varepsilon_\lambda = \varepsilon = 1$
- A graybody, for which $\varepsilon_\lambda = \varepsilon$ = constant less than 1
- A selective radiator, for which ε varies with wavelength

According to Kirchhoff's law, for any material the spectral emissivity and spectral absorptance of a body are equal at any specified temperature and wavelength. That is:

$$\varepsilon_\lambda = \alpha_\lambda$$

From this we obtain, for an opaque material (since $\alpha_\lambda + \rho_\lambda = 1$):

$$\varepsilon_\lambda + \rho_\lambda = 1$$

For highly polished materials ε_λ approaches zero, so that for a perfectly reflecting material (*i.e.* a perfect mirror) we have:

$$\rho_\lambda = 1$$

For a graybody radiator, the Stefan-Boltzmann formula becomes:

$$W = \varepsilon \sigma T^4 \, [\mathrm{Watt/m^2}]$$

This states that the total emissive power of a graybody is the same as a blackbody at the same temperature reduced in proportion to the value of ε from the graybody.

10401203;a2

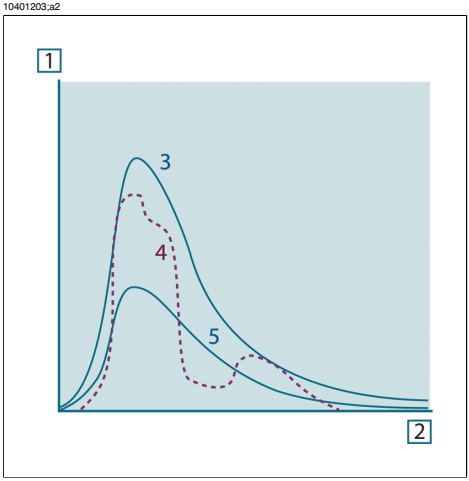


Figure 17.8 Spectral radiant emittance of three types of radiators. **1:** Spectral radiant emittance; **2:** Wavelength; **3:** Blackbody; **4:** Selective radiator; **5:** Graybody.

10327303;a4

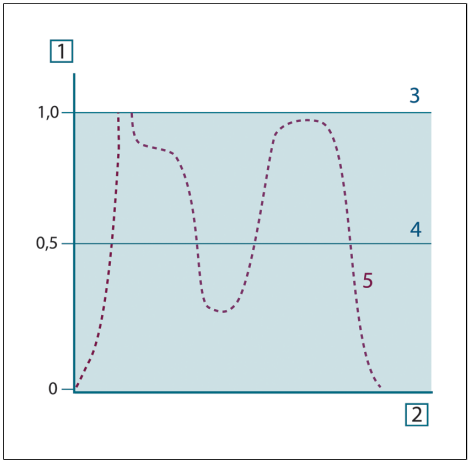


Figure 17.9 Spectral emissivity of three types of radiators. **1:** Spectral emissivity; **2:** Wavelength; **3:** Blackbody; **4:** Graybody; **5:** Selective radiator.

17.4 Infrared semi-transparent materials

Consider now a non-metallic, semi-transparent body – let us say, in the form of a thick flat plate of plastic material. When the plate is heated, radiation generated within its volume must work its way toward the surfaces through the material in which it is partially absorbed. Moreover, when it arrives at the surface, some of it is reflected back into the interior. The back-reflected radiation is again partially absorbed, but

some of it arrives at the other surface, through which most of it escapes; part of it is reflected back again. Although the progressive reflections become weaker and weaker they must all be added up when the total emittance of the plate is sought. When the resulting geometrical series is summed, the effective emissivity of a semi-transparent plate is obtained as:

$$\varepsilon_\lambda = \frac{(1-\rho_\lambda)(1-\tau_\lambda)}{1-\rho_\lambda\tau_\lambda}$$

When the plate becomes opaque this formula is reduced to the single formula:

$$\varepsilon_\lambda = 1-\rho_\lambda$$

This last relation is a particularly convenient one, because it is often easier to measure reflectance than to measure emissivity directly.

18 The measurement formula

As already mentioned, when viewing an object, the camera receives radiation not only from the object itself. It also collects radiation from the surroundings reflected via the object surface. Both these radiation contributions become attenuated to some extent by the atmosphere in the measurement path. To this comes a third radiation contribution from the atmosphere itself.

This description of the measurement situation, as illustrated in the figure below, is so far a fairly true description of the real conditions. What has been neglected could for instance be sun light scattering in the atmosphere or stray radiation from intense radiation sources outside the field of view. Such disturbances are difficult to quantify, however, in most cases they are fortunately small enough to be neglected. In case they are not negligible, the measurement configuration is likely to be such that the risk for disturbance is obvious, at least to a trained operator. It is then his responsibility to modify the measurement situation to avoid the disturbance e.g. by changing the viewing direction, shielding off intense radiation sources etc.

Accepting the description above, we can use the figure below to derive a formula for the calculation of the object temperature from the calibrated camera output.

10400503;a1

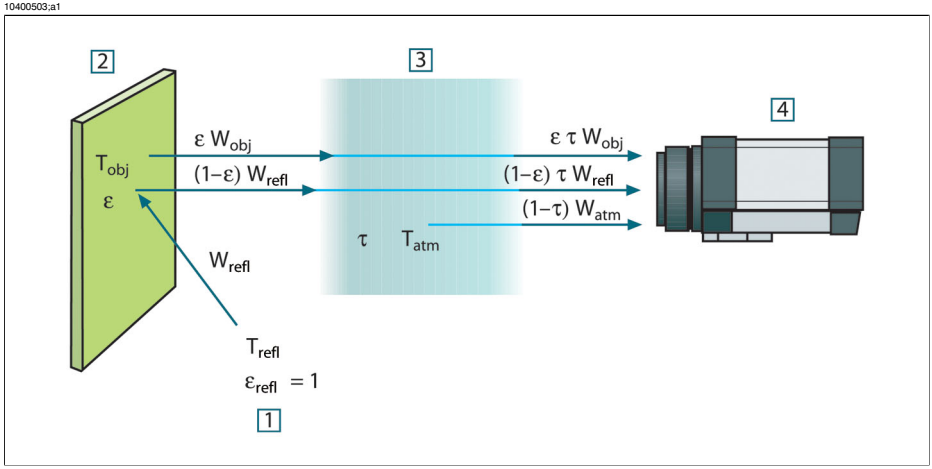


Figure 18.1 A schematic representation of the general thermographic measurement situation.**1:** Surroundings; **2:** Object; **3:** Atmosphere; **4:** Camera

Assume that the received radiation power W from a blackbody source of temperature T_{source} on short distance generates a camera output signal U_{source} that is proportional to the power input (power linear camera). We can then write (Equation 1):

$$U_{source} = CW(T_{source})$$

or, with simplified notation:

$$U_{source} = CW_{source}$$

where C is a constant.

Should the source be a graybody with emittance ε, the received radiation would consequently be εW_{source}.

We are now ready to write the three collected radiation power terms:

1 – Emission from the object = $\varepsilon\tau W_{obj}$, where ε is the emittance of the object and τ is the transmittance of the atmosphere. The object temperature is T_{obj}.

2 – Reflected emission from ambient sources = $(1 - \varepsilon)\tau W_{refl}$, where (1 – ε) is the reflectance of the object. The ambient sources have the temperature T_{refl}.

It has here been assumed that the temperature T_{refl} is the same for all emitting surfaces within the halfsphere seen from a point on the object surface. This is of course sometimes a simplification of the true situation. It is, however, a necessary simplification in order to derive a workable formula, and T_{refl} can – at least theoretically – be given a value that represents an efficient temperature of a complex surrounding.

Note also that we have assumed that the emittance for the surroundings = 1. This is correct in accordance with Kirchhoff's law: All radiation impinging on the surrounding surfaces will eventually be absorbed by the same surfaces. Thus the emittance = 1. (Note though that the latest discussion requires the complete sphere around the object to be considered.)

3 – Emission from the atmosphere = $(1 - \tau)\tau W_{atm}$, where (1 – τ) is the emittance of the atmosphere. The temperature of the atmosphere is T_{atm}.

The total received radiation power can now be written (Equation 2):

$$W_{tot} = \varepsilon\tau W_{obj} + (1 - \varepsilon)\tau W_{refl} + (1 - \tau)W_{atm}$$

We multiply each term by the constant C of Equation 1 and replace the CW products by the corresponding U according to the same equation, and get (Equation 3):

$$U_{tot} = \varepsilon\tau U_{obj} + (1 - \varepsilon)\tau U_{refl} + (1 - \tau)U_{atm}$$

Solve Equation 3 for U_{obj} (Equation 4):

$$U_{obj} = \frac{1}{\varepsilon\tau}U_{tot} - \frac{1-\varepsilon}{\varepsilon}U_{refl} - \frac{1-\tau}{\varepsilon\tau}U_{atm}$$

This is the general measurement formula used in all the FLIR Systems thermographic equipment. The voltages of the formula are:

Figure 18.2 Voltages

U_{obj}	Calculated camera output voltage for a blackbody of temperature T_{obj} i.e. a voltage that can be directly converted into true requested object temperature.
U_{tot}	Measured camera output voltage for the actual case.
U_{refl}	Theoretical camera output voltage for a blackbody of temperature T_{refl} according to the calibration.
U_{atm}	Theoretical camera output voltage for a blackbody of temperature T_{atm} according to the calibration.

The operator has to supply a number of parameter values for the calculation:

- the object emittance ε,
- the relative humidity,
- T_{atm}
- object distance (D_{obj})
- the (effective) temperature of the object surroundings, or the reflected ambient temperature T_{refl}, and
- the temperature of the atmosphere T_{atm}

This task could sometimes be a heavy burden for the operator since there are normally no easy ways to find accurate values of emittance and atmospheric transmittance for the actual case. The two temperatures are normally less of a problem provided the surroundings do not contain large and intense radiation sources.

A natural question in this connection is: How important is it to know the right values of these parameters? It could though be of interest to get a feeling for this problem already here by looking into some different measurement cases and compare the relative magnitudes of the three radiation terms. This will give indications about when it is important to use correct values of which parameters.

The figures below illustrates the relative magnitudes of the three radiation contributions for three different object temperatures, two emittances, and two spectral ranges: SW and LW. Remaining parameters have the following fixed values:

- $\tau = 0.88$
- $T_{refl} = +20°C$ (+68°F)
- $T_{atm} = +20°C$ (+68°F)

It is obvious that measurement of low object temperatures are more critical than measuring high temperatures since the 'disturbing' radiation sources are relatively much stronger in the first case. Should also the object emittance be low, the situation would be still more difficult.

We have finally to answer a question about the importance of being allowed to use the calibration curve above the highest calibration point, what we call extrapolation. Imagine that we in a certain case measure U_{tot} = 4.5 volts. The highest calibration point for the camera was in the order of 4.1 volts, a value unknown to the operator. Thus, even if the object happened to be a blackbody, i.e. $U_{obj} = U_{tot}$, we are actually performing extrapolation of the calibration curve when converting 4.5 volts into temperature.

Let us now assume that the object is not black, it has an emittance of 0.75, and the transmittance is 0.92. We also assume that the two second terms of Equation 4 amount to 0.5 volts together. Computation of U_{obj} by means of Equation 4 then results in U_{obj} = 4.5 / 0.75 / 0.92 – 0.5 = 6.0. This is a rather extreme extrapolation, particularly when considering that the video amplifier might limit the output to 5 volts! Note, though, that the application of the calibration curve is a theoretical procedure where no electronic or other limitations exist. We trust that if there had been no signal limitations in the camera, and if it had been calibrated far beyond 5 volts, the resulting curve would have been very much the same as our real curve extrapolated beyond 4.1 volts, provided the calibration algorithm is based on radiation physics, like the FLIR Systems algorithm. Of course there must be a limit to such extrapolations.

10400603;a2

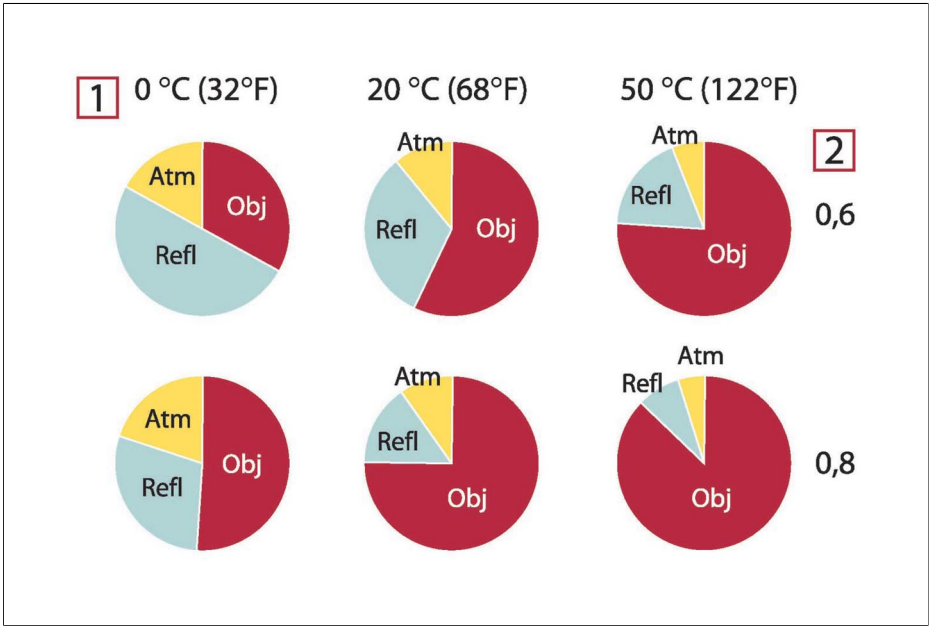


Figure 18.3 Relative magnitudes of radiation sources under varying measurement conditions (SW camera). **1:** Object temperature; **2:** Emittance; **Obj:** Object radiation; **Refl:** Reflected radiation; **Atm:** atmosphere radiation. Fixed parameters: $\tau = 0.88$; $T_{refl} = 20°C$ (+68°F); $T_{atm} = 20°C$ (+68°F).

10400703;a2

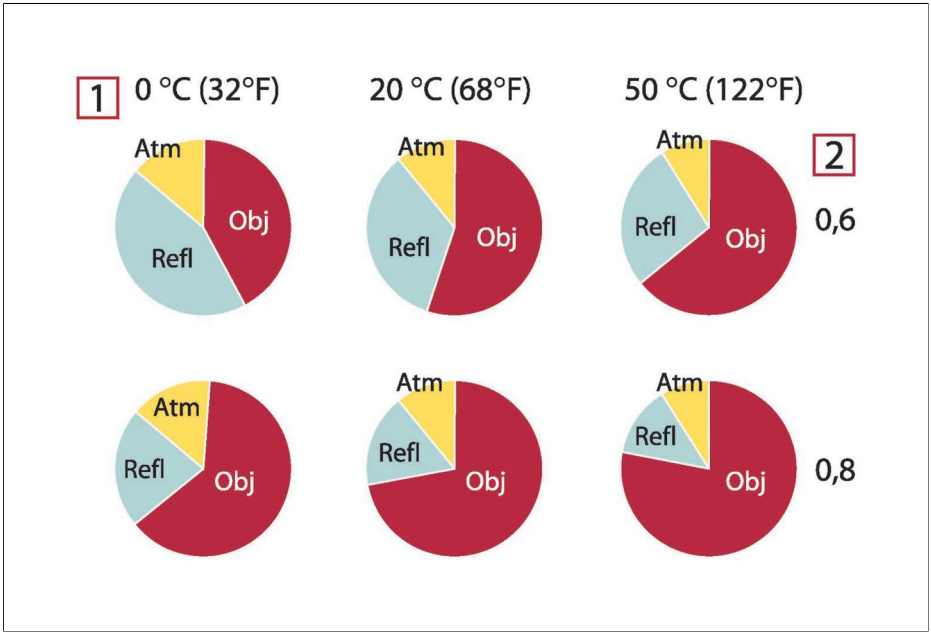


Figure 18.4 Relative magnitudes of radiation sources under varying measurement conditions (LW camera). **1:** Object temperature; **2:** Emittance; **Obj:** Object radiation; **Refl:** Reflected radiation; **Atm:** atmosphere radiation. Fixed parameters: $\tau = 0.88$; $T_{refl} = 20°C$ (+68°F); $T_{atm} = 20°C$ (+68°F).

19 Emissivity tables

This section presents a compilation of emissivity data from the infrared literature and measurements made by FLIR Systems.

19.1 References

1	Mikaél A. Bramson: *Infrared Radiation, A Handbook for Applications*, Plenum press, N.Y.
2	William L. Wolfe, George J. Zissis: *The Infrared Handbook*, Office of Naval Research, Department of Navy, Washington, D.C.
3	Madding, R. P.: *Thermographic Instruments and systems*. Madison, Wisconsin: University of Wisconsin – Extension, Department of Engineering and Applied Science.
4	William L. Wolfe: *Handbook of Military Infrared Technology*, Office of Naval Research, Department of Navy, Washington, D.C.
5	Jones, Smith, Probert: *External thermography of buildings...,* Proc. of the Society of Photo-Optical Instrumentation Engineers, vol.110, Industrial and Civil Applications of Infrared Technology, June 1977 London.
6	Paljak, Pettersson: *Thermography of Buildings*, Swedish Building Research Institute, Stockholm 1972.
7	Vlcek, J: *Determination of emissivity with imaging radiometers and some emissivities at $\lambda = 5$ µm.* Photogrammetric Engineering and Remote Sensing.
8	Kern: *Evaluation of infrared emission of clouds and ground as measured by weather satellites*, Defence Documentation Center, AD 617 417.
9	Öhman, Claes: *Emittansmätningar med AGEMA E-Box*. Teknisk rapport, AGEMA 1999. (Emittance measurements using AGEMA E-Box. Technical report, AGEMA 1999.)
10	Matteï, S., Tang-Kwor, E: *Emissivity measurements for Nextel Velvet coating 811-21 between –36°C AND 82°C.*
11	Lohrengel & Todtenhaupt (1996)
12	ITC Technical publication 32.
13	ITC Technical publication 29.

19.2 Important note about the emissivity tables

The emissivity values in the table below are recorded using a shortwave (SW) camera. The values should be regarded as recommendations only and used with caution.

19.3 Tables

Figure 19.1 T: Total spectrum; **SW:** 2–5 μm; **LW:** 8–14 μm, **LLW:** 6.5–20 μm; **1:** Material; **2:** Specification; **3:** Temperature in °C; **4:** Spectrum; **5:** Emissivity: **6:** Reference

1	2	3	4	5	6
3M type 35	Vinyl electrical tape (several colors)	< 80	LW	Ca. 0.96	13
3M type 88	Black vinyl electrical tape	< 105	LW	Ca. 0.96	13
3M type 88	Black vinyl electrical tape	< 105	MW	< 0.96	13
3M type Super 33+	Black vinyl electrical tape	< 80	LW	Ca. 0.96	13
Aluminum	anodized, black, dull	70	LW	0.95	9
Aluminum	anodized, black, dull	70	SW	0.67	9
Aluminum	anodized, light gray, dull	70	LW	0.97	9
Aluminum	anodized, light gray, dull	70	SW	0.61	9
Aluminum	anodized sheet	100	T	0.55	2
Aluminum	as received, plate	100	T	0.09	4
Aluminum	as received, sheet	100	T	0.09	2
Aluminum	cast, blast cleaned	70	LW	0.46	9
Aluminum	cast, blast cleaned	70	SW	0.47	9
Aluminum	dipped in HNO_3, plate	100	T	0.05	4
Aluminum	foil	27	3 μm	0.09	3
Aluminum	foil	27	10 μm	0.04	3
Aluminum	oxidized, strongly	50–500	T	0.2–0.3	1
Aluminum	polished	50–100	T	0.04–0.06	1
Aluminum	polished, sheet	100	T	0.05	2
Aluminum	polished plate	100	T	0.05	4

1	2	3	4	5	6
Aluminum	roughened	27	3 μm	0.28	3
Aluminum	roughened	27	10 μm	0.18	3
Aluminum	rough surface	20–50	T	0.06–0.07	1
Aluminum	sheet, 4 samples differently scratched	70	LW	0.03–0.06	9
Aluminum	sheet, 4 samples differently scratched	70	SW	0.05–0.08	9
Aluminum	vacuum deposited	20	T	0.04	2
Aluminum	weathered, heavily	17	SW	0.83–0.94	5
Aluminum bronze		20	T	0.60	1
Aluminum hydroxide	powder		T	0.28	1
Aluminum oxide	activated, powder		T	0.46	1
Aluminum oxide	pure, powder (alumina)		T	0.16	1
Asbestos	board	20	T	0.96	1
Asbestos	fabric		T	0.78	1
Asbestos	floor tile	35	SW	0.94	7
Asbestos	paper	40–400	T	0.93–0.95	1
Asbestos	powder		T	0.40–0.60	1
Asbestos	slate	20	T	0.96	1
Asphalt paving		4	LLW	0.967	8
Brass	dull, tarnished	20–350	T	0.22	1
Brass	oxidized	70	SW	0.04–0.09	9
Brass	oxidized	70	LW	0.03–0.07	9
Brass	oxidized	100	T	0.61	2
Brass	oxidized at 600°C	200–600	T	0.59–0.61	1
Brass	polished	200	T	0.03	1
Brass	polished, highly	100	T	0.03	2

1	2	3	4	5	6
Brass	rubbed with 80-grit emery	20	T	0.20	2
Brass	sheet, rolled	20	T	0.06	1
Brass	sheet, worked with emery	20	T	0.2	1
Brick	alumina	17	SW	0.68	5
Brick	common	17	SW	0.86–0.81	5
Brick	Dinas silica, glazed, rough	1100	T	0.85	1
Brick	Dinas silica, refractory	1000	T	0.66	1
Brick	Dinas silica, unglazed, rough	1000	T	0.80	1
Brick	firebrick	17	SW	0.68	5
Brick	fireclay	20	T	0.85	1
Brick	fireclay	1000	T	0.75	1
Brick	fireclay	1200	T	0.59	1
Brick	masonry	35	SW	0.94	7
Brick	masonry, plastered	20	T	0.94	1
Brick	red, common	20	T	0.93	2
Brick	red, rough	20	T	0.88–0.93	1
Brick	refractory, corundum	1000	T	0.46	1
Brick	refractory, magnesite	1000–1300	T	0.38	1
Brick	refractory, strongly radiating	500–1000	T	0.8–0.9	1
Brick	refractory, weakly radiating	500–1000	T	0.65–0.75	1
Brick	silica, 95% SiO_2	1230	T	0.66	1
Brick	sillimanite, 33% SiO_2, 64% Al_2O_3	1500	T	0.29	1

1	2	3	4	5	6
Brick	waterproof	17	SW	0.87	5
Bronze	phosphor bronze	70	LW	0.06	9
Bronze	phosphor bronze	70	SW	0.08	9
Bronze	polished	50	T	0.1	1
Bronze	porous, rough	50–150	T	0.55	1
Bronze	powder		T	0.76–0.80	1
Carbon	candle soot	20	T	0.95	2
Carbon	charcoal powder		T	0.96	1
Carbon	graphite, filed surface	20	T	0.98	2
Carbon	graphite powder		T	0.97	1
Carbon	lampblack	20–400	T	0.95–0.97	1
Chipboard	untreated	20	SW	0.90	6
Chromium	polished	50	T	0.10	1
Chromium	polished	500–1000	T	0.28–0.38	1
Clay	fired	70	T	0.91	1
Cloth	black	20	T	0.98	1
Concrete		20	T	0.92	2
Concrete	dry	36	SW	0.95	7
Concrete	rough	17	SW	0.97	5
Concrete	walkway	5	LLW	0.974	8
Copper	commercial, burnished	20	T	0.07	1
Copper	electrolytic, carefully polished	80	T	0.018	1
Copper	electrolytic, polished	–34	T	0.006	4
Copper	molten	1100–1300	T	0.13–0.15	1
Copper	oxidized	50	T	0.6–0.7	1
Copper	oxidized, black	27	T	0.78	4

1	2	3	4	5	6
Copper	oxidized, heavily	20	T	0.78	2
Copper	oxidized to blackness		T	0.88	1
Copper	polished	50–100	T	0.02	1
Copper	polished	100	T	0.03	2
Copper	polished, commercial	27	T	0.03	4
Copper	polished, mechanical	22	T	0.015	4
Copper	pure, carefully prepared surface	22	T	0.008	4
Copper	scraped	27	T	0.07	4
Copper dioxide	powder		T	0.84	1
Copper oxide	red, powder		T	0.70	1
Ebonite			T	0.89	1
Emery	coarse	80	T	0.85	1
Enamel		20	T	0.9	1
Enamel	lacquer	20	T	0.85–0.95	1
Fiber board	hard, untreated	20	SW	0.85	6
Fiber board	masonite	70	LW	0.88	9
Fiber board	masonite	70	SW	0.75	9
Fiber board	particle board	70	LW	0.89	9
Fiber board	particle board	70	SW	0.77	9
Fiber board	porous, untreated	20	SW	0.85	6
Gold	polished	130	T	0.018	1
Gold	polished, carefully	200–600	T	0.02–0.03	1
Gold	polished, highly	100	T	0.02	2
Granite	polished	20	LLW	0.849	8
Granite	rough	21	LLW	0.879	8
Granite	rough, 4 different samples	70	LW	0.77–0.87	9

1	2	3	4	5	6
Granite	rough, 4 different samples	70	SW	0.95–0.97	9
Gypsum		20	T	0.8–0.9	1
Ice: See Water					
Iron, cast	casting	50	T	0.81	1
Iron, cast	ingots	1000	T	0.95	1
Iron, cast	liquid	1300	T	0.28	1
Iron, cast	machined	800–1000	T	0.60–0.70	1
Iron, cast	oxidized	38	T	0.63	4
Iron, cast	oxidized	100	T	0.64	2
Iron, cast	oxidized	260	T	0.66	4
Iron, cast	oxidized	538	T	0.76	4
Iron, cast	oxidized at 600°C	200–600	T	0.64–0.78	1
Iron, cast	polished	38	T	0.21	4
Iron, cast	polished	40	T	0.21	2
Iron, cast	polished	200	T	0.21	1
Iron, cast	unworked	900–1100	T	0.87–0.95	1
Iron and steel	cold rolled	70	LW	0.09	9
Iron and steel	cold rolled	70	SW	0.20	9
Iron and steel	covered with red rust	20	T	0.61–0.85	1
Iron and steel	electrolytic	22	T	0.05	4
Iron and steel	electrolytic	100	T	0.05	4
Iron and steel	electrolytic	260	T	0.07	4
Iron and steel	electrolytic, carefully polished	175–225	T	0.05–0.06	1
Iron and steel	freshly worked with emery	20	T	0.24	1
Iron and steel	ground sheet	950–1100	T	0.55–0.61	1
Iron and steel	heavily rusted sheet	20	T	0.69	2

1	2	3	4	5	6
Iron and steel	hot rolled	20	T	0.77	1
Iron and steel	hot rolled	130	T	0.60	1
Iron and steel	oxidized	100	T	0.74	1
Iron and steel	oxidized	100	T	0.74	4
Iron and steel	oxidized	125–525	T	0.78–0.82	1
Iron and steel	oxidized	200	T	0.79	2
Iron and steel	oxidized	1227	T	0.89	4
Iron and steel	oxidized	200–600	T	0.80	1
Iron and steel	oxidized strongly	50	T	0.88	1
Iron and steel	oxidized strongly	500	T	0.98	1
Iron and steel	polished	100	T	0.07	2
Iron and steel	polished	400–1000	T	0.14–0.38	1
Iron and steel	polished sheet	750–1050	T	0.52–0.56	1
Iron and steel	rolled, freshly	20	T	0.24	1
Iron and steel	rolled sheet	50	T	0.56	1
Iron and steel	rough, plane surface	50	T	0.95–0.98	1
Iron and steel	rusted, heavily	17	SW	0.96	5
Iron and steel	rusted red, sheet	22	T	0.69	4
Iron and steel	rusty, red	20	T	0.69	1
Iron and steel	shiny, etched	150	T	0.16	1
Iron and steel	shiny oxide layer, sheet,	20	T	0.82	1
Iron and steel	wrought, carefully polished	40–250	T	0.28	1
Iron galvanized	heavily oxidized	70	LW	0.85	9
Iron galvanized	heavily oxidized	70	SW	0.64	9
Iron galvanized	sheet	92	T	0.07	4
Iron galvanized	sheet, burnished	30	T	0.23	1
Iron galvanized	sheet, oxidized	20	T	0.28	1

Publ. No. 1558573 Rev. a476 – ENGLISH (EN) – October 18, 2010

1	2	3	4	5	6
Iron tinned	sheet	24	T	0.064	4
Krylon Ultra-flat black 1602	Flat black	Room temperature up to 175	LW	Ca. 0.96	12
Krylon Ultra-flat black 1602	Flat black	Room temperature up to 175	MW	Ca. 0.97	12
Lacquer	3 colors sprayed on Aluminum	70	LW	0.92–0.94	9
Lacquer	3 colors sprayed on Aluminum	70	SW	0.50–0.53	9
Lacquer	Aluminum on rough surface	20	T	0.4	1
Lacquer	bakelite	80	T	0.83	1
Lacquer	black, dull	40–100	T	0.96–0.98	1
Lacquer	black, matte	100	T	0.97	2
Lacquer	black, shiny, sprayed on iron	20	T	0.87	1
Lacquer	heat–resistant	100	T	0.92	1
Lacquer	white	40–100	T	0.8–0.95	1
Lacquer	white	100	T	0.92	2
Lead	oxidized, gray	20	T	0.28	1
Lead	oxidized, gray	22	T	0.28	4
Lead	oxidized at 200°C	200	T	0.63	1
Lead	shiny	250	T	0.08	1
Lead	unoxidized, polished	100	T	0.05	4
Lead red		100	T	0.93	4
Lead red, powder		100	T	0.93	1
Leather	tanned		T	0.75–0.80	1
Lime			T	0.3–0.4	1
Magnesium		22	T	0.07	4
Magnesium		260	T	0.13	4

1	2	3	4	5	6
Magnesium		538	T	0.18	4
Magnesium	polished	20	T	0.07	2
Magnesium powder			T	0.86	1
Molybdenum		600–1000	T	0.08–0.13	1
Molybdenum		1500–2200	T	0.19–0.26	1
Molybdenum	filament	700–2500	T	0.1–0.3	1
Mortar		17	SW	0.87	5
Mortar	dry	36	SW	0.94	7
Nextel Velvet 811-21 Black	Flat black	–60–150	LW	> 0.97	10 and 11
Nichrome	rolled	700	T	0.25	1
Nichrome	sandblasted	700	T	0.70	1
Nichrome	wire, clean	50	T	0.65	1
Nichrome	wire, clean	500–1000	T	0.71–0.79	1
Nichrome	wire, oxidized	50–500	T	0.95–0.98	1
Nickel	bright matte	122	T	0.041	4
Nickel	commercially pure, polished	100	T	0.045	1
Nickel	commercially pure, polished	200–400	T	0.07–0.09	1
Nickel	electrolytic	22	T	0.04	4
Nickel	electrolytic	38	T	0.06	4
Nickel	electrolytic	260	T	0.07	4
Nickel	electrolytic	538	T	0.10	4
Nickel	electroplated, polished	20	T	0.05	2
Nickel	electroplated on iron, polished	22	T	0.045	4
Nickel	electroplated on iron, unpolished	20	T	0.11–0.40	1

1	2	3	4	5	6
Nickel	electroplated on iron, unpolished	22	T	0.11	4
Nickel	oxidized	200	T	0.37	2
Nickel	oxidized	227	T	0.37	4
Nickel	oxidized	1227	T	0.85	4
Nickel	oxidized at 600°C	200–600	T	0.37–0.48	1
Nickel	polished	122	T	0.045	4
Nickel	wire	200–1000	T	0.1–0.2	1
Nickel oxide		500–650	T	0.52–0.59	1
Nickel oxide		1000–1250	T	0.75–0.86	1
Oil, lubricating	0.025 mm film	20	T	0.27	2
Oil, lubricating	0.050 mm film	20	T	0.46	2
Oil, lubricating	0.125 mm film	20	T	0.72	2
Oil, lubricating	film on Ni base: Ni base only	20	T	0.05	2
Oil, lubricating	thick coating	20	T	0.82	2
Paint	8 different colors and qualities	70	LW	0.92–0.94	9
Paint	8 different colors and qualities	70	SW	0.88–0.96	9
Paint	Aluminum, various ages	50–100	T	0.27–0.67	1
Paint	cadmium yellow		T	0.28–0.33	1
Paint	chrome green		T	0.65–0.70	1
Paint	cobalt blue		T	0.7–0.8	1
Paint	oil	17	SW	0.87	5
Paint	oil, black flat	20	SW	0.94	6
Paint	oil, black gloss	20	SW	0.92	6
Paint	oil, gray flat	20	SW	0.97	6
Paint	oil, gray gloss	20	SW	0.96	6
Paint	oil, various colors	100	T	0.92–0.96	1

1	2	3	4	5	6
Paint	oil based, average of 16 colors	100	T	0.94	2
Paint	plastic, black	20	SW	0.95	6
Paint	plastic, white	20	SW	0.84	6
Paper	4 different colors	70	LW	0.92–0.94	9
Paper	4 different colors	70	SW	0.68–0.74	9
Paper	black		T	0.90	1
Paper	black, dull		T	0.94	1
Paper	black, dull	70	LW	0.89	9
Paper	black, dull	70	SW	0.86	9
Paper	blue, dark		T	0.84	1
Paper	coated with black lacquer		T	0.93	1
Paper	green		T	0.85	1
Paper	red		T	0.76	1
Paper	white	20	T	0.7–0.9	1
Paper	white, 3 different glosses	70	LW	0.88–0.90	9
Paper	white, 3 different glosses	70	SW	0.76–0.78	9
Paper	white bond	20	T	0.93	2
Paper	yellow		T	0.72	1
Plaster		17	SW	0.86	5
Plaster	plasterboard, untreated	20	SW	0.90	6
Plaster	rough coat	20	T	0.91	2
Plastic	glass fibre laminate (printed circ. board)	70	LW	0.91	9
Plastic	glass fibre laminate (printed circ. board)	70	SW	0.94	9

1	2	3	4	5	6
Plastic	polyurethane isolation board	70	LW	0.55	9
Plastic	polyurethane isolation board	70	SW	0.29	9
Plastic	PVC, plastic floor, dull, structured	70	LW	0.93	9
Plastic	PVC, plastic floor, dull, structured	70	SW	0.94	9
Platinum		17	T	0.016	4
Platinum		22	T	0.03	4
Platinum		100	T	0.05	4
Platinum		260	T	0.06	4
Platinum		538	T	0.10	4
Platinum		1000–1500	T	0.14–0.18	1
Platinum		1094	T	0.18	4
Platinum	pure, polished	200–600	T	0.05–0.10	1
Platinum	ribbon	900–1100	T	0.12–0.17	1
Platinum	wire	50–200	T	0.06–0.07	1
Platinum	wire	500–1000	T	0.10–0.16	1
Platinum	wire	1400	T	0.18	1
Porcelain	glazed	20	T	0.92	1
Porcelain	white, shiny		T	0.70–0.75	1
Rubber	hard	20	T	0.95	1
Rubber	soft, gray, rough	20	T	0.95	1
Sand			T	0.60	1
Sand		20	T	0.90	2
Sandstone	polished	19	LLW	0.909	8
Sandstone	rough	19	LLW	0.935	8
Silver	polished	100	T	0.03	2
Silver	pure, polished	200–600	T	0.02–0.03	1

1	2	3	4	5	6
Skin	human	32	T	0.98	2
Slag	boiler	0–100	T	0.97–0.93	1
Slag	boiler	200–500	T	0.89–0.78	1
Slag	boiler	600–1200	T	0.76–0.70	1
Slag	boiler	1400–1800	T	0.69–0.67	1
Snow: See Water					
Soil	dry	20	T	0.92	2
Soil	saturated with water	20	T	0.95	2
Stainless steel	alloy, 8% Ni, 18% Cr	500	T	0.35	1
Stainless steel	rolled	700	T	0.45	1
Stainless steel	sandblasted	700	T	0.70	1
Stainless steel	sheet, polished	70	LW	0.14	9
Stainless steel	sheet, polished	70	SW	0.18	9
Stainless steel	sheet, untreated, somewhat scratched	70	LW	0.28	9
Stainless steel	sheet, untreated, somewhat scratched	70	SW	0.30	9
Stainless steel	type 18-8, buffed	20	T	0.16	2
Stainless steel	type 18-8, oxidized at 800°C	60	T	0.85	2
Stucco	rough, lime	10–90	T	0.91	1
Styrofoam	insulation	37	SW	0.60	7
Tar			T	0.79–0.84	1
Tar	paper	20	T	0.91–0.93	1
Tile	glazed	17	SW	0.94	5
Tin	burnished	20–50	T	0.04–0.06	1
Tin	tin–plated sheet iron	100	T	0.07	2

1	2	3	4	5	6
Titanium	oxidized at 540°C	200	T	0.40	1
Titanium	oxidized at 540°C	500	T	0.50	1
Titanium	oxidized at 540°C	1000	T	0.60	1
Titanium	polished	200	T	0.15	1
Titanium	polished	500	T	0.20	1
Titanium	polished	1000	T	0.36	1
Tungsten		200	T	0.05	1
Tungsten		600–1000	T	0.1–0.16	1
Tungsten		1500–2200	T	0.24–0.31	1
Tungsten	filament	3300	T	0.39	1
Varnish	flat	20	SW	0.93	6
Varnish	on oak parquet floor	70	LW	0.90–0.93	9
Varnish	on oak parquet floor	70	SW	0.90	9
Wallpaper	slight pattern, light gray	20	SW	0.85	6
Wallpaper	slight pattern, red	20	SW	0.90	6
Water	distilled	20	T	0.96	2
Water	frost crystals	–10	T	0.98	2
Water	ice, covered with heavy frost	0	T	0.98	1
Water	ice, smooth	–10	T	0.96	2
Water	ice, smooth	0	T	0.97	1
Water	layer >0.1 mm thick	0–100	T	0.95–0.98	1
Water	snow		T	0.8	1
Water	snow	–10	T	0.85	2
Wood		17	SW	0.98	5
Wood		19	LLW	0.962	8
Wood	ground		T	0.5–0.7	1

1	2	3	4	5	6
Wood	pine, 4 different samples	70	LW	0.81–0.89	9
Wood	pine, 4 different samples	70	SW	0.67–0.75	9
Wood	planed	20	T	0.8–0.9	1
Wood	planed oak	20	T	0.90	2
Wood	planed oak	70	LW	0.88	9
Wood	planed oak	70	SW	0.77	9
Wood	plywood, smooth, dry	36	SW	0.82	7
Wood	plywood, untreated	20	SW	0.83	6
Wood	white, damp	20	T	0.7–0.8	1
Zinc	oxidized at 400°C	400	T	0.11	1
Zinc	oxidized surface	1000–1200	T	0.50–0.60	1
Zinc	polished	200–300	T	0.04–0.05	1
Zinc	sheet	50	T	0.20	1

20 Glossary

Term or expression	Explanation
absorption (absorption factor)	The amount of radiation absorbed by an object relative to the received radiation. A number between 0 and 1.
atmosphere	The gases between the object being measured and the camera, normally air.
autoadjust	A function making a camera perform an internal image correction.
autopalette	The IR image is shown with an uneven spread of colors, displaying cold objects as well as hot ones at the same time.
blackbody	Totally non-reflective object. All its radiation is due to its own temperature.
blackbody radiator	An IR radiating equipment with blackbody properties used to calibrate IR cameras.
calculated atmospheric transmission	A transmission value computed from the temperature, the relative humidity of air and the distance to the object.
cavity radiator	A bottle shaped radiator with an absorbing inside, viewed through the bottleneck.
color temperature	The temperature for which the color of a blackbody matches a specific color.
conduction	The process that makes heat diffuse into a material.
continuous adjust	A function that adjusts the image. The function works all the time, continuously adjusting brightness and contrast according to the image content.
convection	Convection is a heat transfer mode where a fluid is brought into motion, either by gravity or another force, thereby transferring heat from one place to another.
dual isotherm	An isotherm with two color bands, instead of one.
emissivity (emissivity factor)	The amount of radiation coming from an object, compared to that of a blackbody. A number between 0 and 1.
emittance	Amount of energy emitted from an object per unit of time and area (W/m^2)
environment	Objects and gases that emit radiation towards the object being measured.
estimated atmospheric transmission	A transmission value, supplied by a user, replacing a calculated one

Term or expression	Explanation
external optics	Extra lenses, filters, heat shields etc. that can be put between the camera and the object being measured.
filter	A material transparent only to some of the infrared wavelengths.
FOV	Field of view: The horizontal angle that can be viewed through an IR lens.
FPA	Focal plane array: A type of IR detector.
graybody	An object that emits a fixed fraction of the amount of energy of a blackbody for each wavelength.
IFOV	Instantaneous field of view: A measure of the geometrical resolution of an IR camera.
image correction (internal or external)	A way of compensating for sensitivity differences in various parts of live images and also of stabilizing the camera.
infrared	Non-visible radiation, having a wavelength from about 2–13 µm.
IR	infrared
isotherm	A function highlighting those parts of an image that fall above, below or between one or more temperature intervals.
isothermal cavity	A bottle-shaped radiator with a uniform temperature viewed through the bottleneck.
Laser LocatIR	An electrically powered light source on the camera that emits laser radiation in a thin, concentrated beam to point at certain parts of the object in front of the camera.
laser pointer	An electrically powered light source on the camera that emits laser radiation in a thin, concentrated beam to point at certain parts of the object in front of the camera.
level	The center value of the temperature scale, usually expressed as a signal value.
manual adjust	A way to adjust the image by manually changing certain parameters.
NETD	Noise equivalent temperature difference. A measure of the image noise level of an IR camera.
noise	Undesired small disturbance in the infrared image
object parameters	A set of values describing the circumstances under which the measurement of an object was made, and the object itself (such as emissivity, reflected apparent temperature, distance etc.)
object signal	A non-calibrated value related to the amount of radiation received by the camera from the object.

Term or expression	Explanation
palette	The set of colors used to display an IR image.
pixel	Stands for *picture element*. One single spot in an image.
radiance	Amount of energy emitted from an object per unit of time, area and angle ($W/m^2/sr$)
radiant power	Amount of energy emitted from an object per unit of time (W)
radiation	The process by which electromagnetic energy, is emitted by an object or a gas.
radiator	A piece of IR radiating equipment.
range	The current overall temperature measurement limitation of an IR camera. Cameras can have several ranges. Expressed as two blackbody temperatures that limit the current calibration.
reference temperature	A temperature which the ordinary measured values can be compared with.
reflection	The amount of radiation reflected by an object relative to the received radiation. A number between 0 and 1.
relative humidity	Relative humidity represents the ratio between the current water vapour mass in the air and the maximum it may contain in saturation conditions.
saturation color	The areas that contain temperatures outside the present level/span settings are colored with the saturation colors. The saturation colors contain an 'overflow' color and an 'underflow' color. There is also a third red saturation color that marks everything saturated by the detector indicating that the range should probably be changed.
span	The interval of the temperature scale, usually expressed as a signal value.
spectral (radiant) emittance	Amount of energy emitted from an object per unit of time, area and wavelength ($W/m^2/\mu m$)
temperature difference, or difference of temperature.	A value which is the result of a subtraction between two temperature values.
temperature range	The current overall temperature measurement limitation of an IR camera. Cameras can have several ranges. Expressed as two blackbody temperatures that limit the current calibration.
temperature scale	The way in which an IR image currently is displayed. Expressed as two temperature values limiting the colors.
thermogram	infrared image

Term or expression	Explanation
transmission (or transmittance) factor	Gases and materials can be more or less transparent. Transmission is the amount of IR radiation passing through them. A number between 0 and 1.
transparent isotherm	An isotherm showing a linear spread of colors, instead of covering the highlighted parts of the image.
visual	Refers to the video mode of a IR camera, as opposed to the normal, thermographic mode. When a camera is in video mode it captures ordinary video images, while thermographic images are captured when the camera is in IR mode.

INTENTIONALLY LEFT BLANK

A note on the technical production of this publication

This publication was produced using XML—the *eXtensible Markup Language*. For more information about XML, please visit http://www.w3.org/XML/

A note on the typeface used in this publication

This publication was typeset using Swiss 721, which is Bitstream's pan-European version of the Helvetica™ typeface. Helvetica™ was designed by Max Miedinger (1910–1980).

List of effective files

20235103.xml a24
20235203.xml a21
20235303.xml a18
20236703.xml a49
20237103.xml a10
20238503.xml a9
20238703.xml b8
20250403.xml a20
20254903.xml a63
20257003.xml a40
20277903.xml a12
20279903.xml a14
20280003.xml a4
20280103.xml a9
20280203.xml a6
20280603.xml a10
20280703.xml a12
20281203.xml a2
20281403.xml a6
20281503.xml a5
20287303.xml a9
20292403.xml a5
20294403.xml a6
R0101.rcp a20
config.xml a5

Corporate Headquarters
FLIR Systems, Inc.
27700 SW Parkway Avenue
Wilsonville, OR 97070
USA
Telephone: +1-800-727-3547
Website: http://www.flir.com